NOTE

This Microfiche meets the quality requirements of the American National Standard for Microfiche of Documents (ANSI PH5.9-1975). However, because of imperfections in the document from which it was made, it contains images that are illegible or difficult to read. The source document for this microfiche is the best copy that could be obtained prior to filming.

CIS Congressional Information Service, Inc
Washington, D.C

PB85-218329

Preventing Illness and Injury in the Workplace

VOL. II—PART A: WORKING PAPERS

#1—Data on Occupational Injuries and Illnesses
#2—An Analysis of OSHA Health Inspection Data
#3—Historical Perspective: The Evolution of the Definition of Certain Work-Related Illnesses
#4—A History of Occupational Safety and Health in the United States
#5—A History of the Consideration of Economic Impacts in the Determination of the Feasibility
of Standards Under the OSH Act
#6—Decision Frameworks to Enhance Occupational Health and Safety Regulation
#7—A Critique of Cost-Benefit Analysis as a Technique for Determining Health Standards
Under the Occupational Safety and Health Act
#8—Non-Regulatory Legal Incentives for the Adoption of Occupational Safety
and Health Control Technologies

CONGRESS OF THE UNITED STATES
Office of Technology Assessment
Washington, D. C. 20510

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

J952-74

PB85-218329

Preventing Illness and Injury in the Workplace
Volume 2-Part A: Working Papers

(U.S.) Office of Technology Assessment
Washington, DC

Dec 84

U.S. Department of Commerce
National Technical Information Service
NTIS

J952-74

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO.

2.

3. Recipient's Accession No.
PB85 218329/AS

4. Title and Subtitle
Preventing Illness and Injury in the Workplace
Volume II-Part A :Working Papers

5. Report Date

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Same as box 12.

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Office of Technology Assessment
U.S. Congress
Washington, D.C. 20510

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This volume is one three volumes of working papers prepared as background information for OTA's assessment: Preventing Illness and Injury in the Workplace.

17. Document Analysis a. Descriptors

safety
prevention
hazards
environmental engineering
office management
regulations
government policies
standards

b. Identifiers/Open-Ended Terms

Occupational Safety and Health Administration
health standards
technology assessment

c. COSATI Field/Group

18. Availability Statement

19. Security Class (This Report)

20. Security Class (This Page)

21. No. of Pages
668

22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)

PREFACE

This volume consists of working papers prepared for the OTA assessment Preventing Illness and Injury in the Workplace. These working papers have not been reviewed or approved by the Technology Assessment Board.

Preventing Illness and Injury in the Workplace

Volume II — Working Papers

PART A:

# 1 — Kronebusch, K., *Data on Occupational Injuries and Illnesses*, working paper, December 1984.

# 2 -- Mendeloff, J., *An Analysis of OSHA Health Inspection Data*, contract report, April 1983.

# 3 — Corn, J. C., *Historical Perspective: The Evolution of the Definition of Certain Work-Related Illnesses*, contract report, July 1983.

# 4 — Kent, H., *A History of Occupational Safety and Health in the United States*, contract report, April 1983.

# 5 — MacLean, D., *A History of the Consideration of Economic Impacts in the Determination of the Feasibility of Standards Under the OSH Act*, contract report, April 1983.

# 6 — Lave, J. R., and Lave, L. B., *Decision Frameworks to Enhance Occupational Health and Safety Regulation*. contract report, February 1983.

# 7 — MacLean, D. and Sagoff, M., *A Critique of Cost-Benefit Analysis as a Technique for Determining Health Standards under the Occupational Safety and Health Act*, contract report, April 1983.

# 8 — Harter, P., *Non-Regulatory Legal Incentives for the Adoption of Occupational Safety and Health Control Technologies*, contract report, April 1983.

PREVENTING ILLNESS AND INJURY IN THE WORKPLACE

WORKING PAPER

DATA ON OCCUPATIONAL INJURIES AND ILLNESSES

by

KARL KRONEBUSCH

Office of Technology Assessment
Congress of the United States of America

DECEMBER 1984

TABLE OF CONTENTS

Description Of Information Sources....1
OSHA/BLS Data Collection....1
Pre-1970 Data Collection....1
Post-1970 Data Collection....4
BLS Annual Survey....7
Uses of the Annual Survey Data and the OSHA Log....8
BLS Supplementary Data System....10
Work Injury Report Survey Program....11
OSHA Fatality/Catastrophe Investigations....12
Other Sources....14
National Safety Council....14
The National Center for Health Statistics....14
National Institute for Occupational Safety and Health....15
Social Security Administration....16
Public Employee Statistical Collection....17

Number of Occupational Injuries....17
Fatalities....17
BLS-NSC Discrepancy....18
Other Sources....19
OTA Estimate....25
Nonfatal Workplace Injuries....26
National Safety Council....26
BLS....27
Federal Employees....27
Workers' Compensation Cases....28
State and Local Government Employees....28
National Health Interview Survey....28
National Electronic Injury Surveillance System....31
Distribution of Injuries and Illnesses....31
Occupational Fatalities....31
Nonfatal Occupational Injuries and Illnesses....33
Published Analyses Using SDS Data....36

Injury Trends and OSHA's Impact....40
Description of Trends....40
Nonfatal Injuries....40
Fatalities....41
Factors That Influence Injury Rate Trends....42
Injury Rate Trends, the Business Cycle, and OSHA Policies....44
Studies on the Impact of OSHA on Injury Rates....50
Description of Studies....53
Summary on OSHA's Impact....61
Effects of Mine Safety Regulation....63
Potential of Safety Regulation....64

Accuracy and Adequacy of Employer-Maintained Records....................66
    Previous Research..69
    Comparison of Annual Survey and Supplementary Data System...........75
    Comparison of Annual Survey and National Health Interview Survey....80
    Summary of Comparisons...83

Occupational Illnesses...85
    Number of Occupationally-Related Disease Cases......................85
    Prevalence of Occupationally-Related Disability.......................92
    Discher Study..93
    Data on Exposure...95
    Trends in Exposure Levels and The Impact of OSHA......................97
    Conclusion on Occupational Illness and Exposure Data...............103

References...105

Tables and Figures..115

Description Of Information Sources

OSHA/BLS Data Collection

Pre-1970 Data Collection. The Bureau of Labor Statistics (BLS) of the Department of Labor has been collecting information on occupational injuries since at least 1910, when it conducted a study of the iron and steel industry. By 1925-6, using state records, a series of accident frequency and severity reports had been established and, over time, were gradually expanded (Schauer and Ryder, p. 14). The collected data were of varying quality and tended to be very closely tied to the worker's compensation systems of the various states.

During the 1960's, the BLS administered annual employer surveys, in cooperation with a number of state agencies. These surveys were not designed to generate estimates of the aggregate number of work injuries in the nation as a whole, but only to estimate accident frequency rates for various industries in the cooperating states. The injury rates for manufacturing from this survey for 1960 through 1970 are presented in Figure 1. During the course of the debates concerning the Occupational Safety and Health Act of 1970, many observers pointed to this general rise in work injury frequency as evidence of the need for a new federal agency to administer job safety in the U.S.

Congress also discussed the adequacy of that BLS-collected data, spurred in part by research conducted by a team led by Jerome Gordon. These researched reached several main conclusions. First, the pre-1970 survey results were not representative of American business because the BLS sample was heavily concentrated in manufacturing, dominated by large employers, and geographically concentrated in the New England, Middle Atlantic, and East North Central states (Gordon, pp. 10-11). Moreover, there was little consistency among the states concerning sample selection and data editing. (Gordon, p. 38).

Second, Gordon and his team found numerous inconsistencies between responses to the voluntary BLS survey and reports filed for workers' compensation. They conducted a study of the quality of the BLS survey in one state—California. For that state they were able to make a direct comparison of BLS survey responses and workers' compensation reports for 121 firms in 1967 and 119 firms in 1968. For each of the two years, they found that only about one-quarter of the firms reported the same number of injuries to both BLS and the workers' compensation agency. About 1/3 of the firms reported fewer injuries to BLS than to workers' compensation. These firms reported about 44 percent more injuries to the workers' compensation agency. About 40 percent of the firms apparently reported more to BLS than to workers' compensation. As Gordon points out, the major causes of the apparent 40 percent underreporting to workers' compensation may have been due to misfilings, errors in classification, and missing reports (Gordon, p. 108-9).

The underreporting to BLS was particularly striking for the 55 firms who had reported no injuries at all to BLS. For 20 of those firms, Gordon and his team found workers' compensation reports. In this sample, then, about 36 percent of these firms reporting no disabling injuries actually had such injuries. These firms constituted about 8 percent of the 240 firms in the matched groups (Gordon, pp. 108-9).

Third, they concluded that many "serious" injuries were not being included in the BLS estimates. They based this on a comprehensive examination of a sample of firms that reported to the BLS survey to learn about their injury reporting systems and their safety activities. Two thirds of the firms surveyed had the internal resources to provide information on serious injuries that according to the prevailing voluntary standard concerning recordkeeping on injuries (American National Standards Institute (ANSI) Standard # Z16.1) were not "disabling" because they did not involve death, permanent disability, or loss of work time beyond the day of the accident. Gordon asked these firms to compile counts of injuries that involved:

1. Eye injuries,
2. Loss of consciousness,
3. Fractures,
4. Hospitalization for observation
5. Physician treatment,
6. Restriction of work or motion or assignment to another job.

These injuries were combined with the number of "disabling" injuries reported to BLS to develop a count of the number of "serious" injuries. The ratio of "serious" injuries to "disabling" injuries reported to BLS was about 10 to 1 (Gordon, p. 155).

After hearing testimony on this situation, both Congressional committees who worked on the writing of the OSH Act concluded that the system then in operation was inadequate. The House Committee on Education and Labor noted:

> adequate information is the precondition for responsive administration of practically all sections of this bill. However, at the present time, the Federal Government and most of the States have inadequate information on the incidence, nature, or cause of occupational injuries and deaths. For diseases, the information gap is even larger. Thus, the first action of both the Federal and State Governments should be to remedy these gaps with the

> institution of adequate statistical programs. The long-standing charade of the Z16 standard is specifically recognized and rejected by the language of the Committee bill which requires, that all deaths, injuries and ailments should be recorded at least once. (House Report 91-1291, p. 30)

The House Committee's mention of the "charade of the Z16 standard" was a reference to the provisions of an ANSI standard which allowed employers, through the use of job transfers and light-duty work, to avoid reporting injuries as "disabling." The Senate Committee on Labor and Public Welfare concurred with the House Committee in calling for better data collection. In section 8(c)(2) of the Occupational Safety and Health Act, Congress mandated that a new, uniform system of injury and illness recordkeeping be created.

Post-1970 Data Collection. Even before passage of the OSH Act, the Department of Labor had begun planning for a new, national system for the collection of occupational health and safety statistics. Then Under-Secretary of Labor J.D. Hodgson asked the American National Standards Institute to evaluate its Z16.1 standard for use in such a system. ANSI formed a study group which concluded that the Z16.1 standard was too complex for such a mandatory, national system. Moreover, its provisions concerning job transfer after injury allowed some firms to lower their apparent injury rates artificially. The Z16.1 standard also did not include any provisions for recording information on occupational illness. The study group recommended a new system. Most of this study group's proposals were incorporated in the recordkeeping regulation published by the Labor Department in July 1971 (Schauer and Ryder, pp. 14-5).

Those requirements currently mandate that most private employers keep records on injuries and illnesses occurring in their workplaces. Certain categories of employers are exempt from these requirements: small employers who employed no more than 10 full-time or part-time employees at any one time during the year, employers of domestics for housekeeping or child care in the employer's private residence, and religious employers, but only for employee time spent in the conduct of religious services. Injuries and illnesses occurring during secular activities must be recorded. On December 28, 1982, OSHA added employers in certain industries with generally low injury rates to this list of excluded workplaces.

For the purposes of OSHA recordkeeping and the BLS annual survey, occupational injuries and illnesses have been defined. An occupational injury is "any injury such as a cut, fracture, sprain, amputation, etc., which results from a work accident or from an exposure involving a single incident in the work environment." An occupational illness is "any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to environmental factors associated with employment. It includes acute and chronic illnesses or diseases which may be caused by inhalation, absorption, ingestion, or direct contact." (OSHA, Recordkeeping Requirements) In general, an injury or illness is required to be recorded only if resulted in

1. death,
2. lost work time
3. transfer to another job or termination of employment,
4. medical treatment beyond first aid,
5. loss of consciousness or restriction of work or motion, or
6. a diagnosed occupational illness reported to the employer.

Cases with lost work time included both those with actual "days away from work" or days on which the employee would have worked but did not because of the injury or illness, as well as days of "restricted work activity." A workday needs to be counted as a day of "restricted work activity" if

1. the employee was assigned to another job on a temporary basis,
2. the employee worked at a permanent job less than full time, or
3. the employee worked at a permanently assigned job but could not perform all duties normally connected with it. (OSHA Recordkeeping Requirements)

The day of the injury or the onset of the illness is not to be included as a lost workday.

"Medical treatment" is defined to cover treatment "administered by a physician or by a registered professional under the standing orders of a physician. It does not include first-aid treatment of minor scratches, cuts, burns, splinters, etc. which ordinarily do not require medical care, even if such first-aid is provided by a physician or registered professional" (Recordkeeping Requirements).

Employers are required to maintain two records to comply with OSHA recordkeeping requirements. First is the Log and Summary of Occupational Injuries and Illnesses, also known as the OSHA Form 200 or the OSHA Log. Various pieces of information concerning each injury or illness must be recorded on the Log, including the injured employee's name, occupation and department, a brief description of the injury or illness, the date of occurrence, the number of lost workdays (if any), and the number of days of restricted activity (if any). This Log must be maintained during the year and the summary portion must be posted in the workplace by the employer during February of the following year.

In addition, for each "recordable" injury or illness (a "recordable case is one that must be recorded, see requirements above), a Supplementary Record needs to be made, including a number of more detailed descriptions of the nature of the injury and the circumstances surrounding its occurrence. Employers may, but are not required to, use the OSHA Form 101 for this purpose. Workers' compensation, insurance company, or other reports can be used as substitutes if they provide at least all of the information required by the OSHA 101 (OSHA, Recordkeeping Requirements, p. 2). In most cases, employers use their Employer's First Reports of Injury, required for workers' compensation purposes, as a substitute for the OSHA 101.

It should be noted that, in general, employers only need to keep and maintain these records at their place of business and make them available for OSHA inspection. They do not need to send any records to BLS or OSHA. If they are selected to participate in the BLS Annual Survey, they must complete the BLS questionnaire. Employers are, however, required to notify OSHA within 48 hours of any accident that results in a fatality or the hospitalization of 5 or more employees.

BLS Annual Survey. The Bureau of Labor Statistics has since 1973 conducted an annual survey of employers to estimate the number of and incidence rates for "recordable" occupational injuries and illnesses in the private sector. It currently surveys about 280,000 establishments.

Some employers are ordinarily not required to keep records of occupational injuries and illnesses. These include, for example, agricultural employers with fewer than 11 employees and employers from certain low-risk nonmanufacturing industries with fewer than 11 employees. Some of these employers are still selected to participate in the BLS annual survey. BLS notifies them in December of the preceding year that they will be required to maintain OSHA records for the following survey year.

Employers selected for the survey report the number of occupational injuries & illnesses that occurred during the preceding year among their employees. They are asked to report the number of work-related fatalities, nonfatal injuries, injuries involving lost worktime, injuries involving restricted work activity, and the total number of lost workdays. They also must report the number of work-related illnesses but, for reasons discussed below, illness information is very limited.

BLS also requests information on average annual employment and total hours worked in order to calculate incidence rates. BLS, directly or in cooperation with state agencies, collects the data for most industries. Data, conforming to the BLS definitions and methodology, are collected for mining by the Mine Safety and Health Administration (MSHA). Similarly, the Federal Railroad Administration collects data for railroads. BLS includes these data on mining and railroads in their publications.

BLS estimates injury and illness rates by detailed industry classification for the nation and has available similar data for 39 states. The national survey results are published annually, and computer tapes of the data are available. The state data are available from the National Technical Information Service (NTIS) (Schaffer, letter).

Uses of the Annual Survey Data and the OSHA Log. OSHA uses the Annual Survey data to target its safety inspections towards the more hazardous industries. Information from the Annual Survey on injury rates by industry is combined with lists of establishments by industry to generate lists of establishments with 11 or more employees in the relatively more hazardous industries for each OSHA area office. OSHA uses these lists when planning programmed safety inspections. (See discussion of enforcement activity in Chapter 12 of Preventing Illness and Injury in the Workplace.)

When conducting an inspection, OSHA has the right, under the OSH Act, to require that the employer furnish a copy of the log to the compliance officer. Until 1981, compliance officers used the logs only to learn about the general safety of the plant and to find specific departments or locations within the plant that might deserve special scrutiny.

On October 1, 1981, OSHA began a new policy concerning the use of the logs. Upon arrival for a programmed safety inspection, compliance officers now request the establishment's Logs for the previous two years (three years for establishments with fewer than 20 employees). They use those logs and information on the number of employees or employee hours worked to calculate an average incidence rate for lost workday injury cases for the establishment. The resulting rate is compared to the latest published national average for manufacturing. If the establishment has a rate lower than the national manufacturing rate, the compliance officer terminates the inspection at that point. If the establishment rate is higher, the officer will conduct a safety inspection (See OSHA Instruction, CPL 2.25B, Oct. 1, 1981).

When the policy was first implemented in 1981, establishments that had a lost workday injury rate below 5.7 cases per 100 full-time workers would not be inspected unless the inspection has been scheduled in response to an employee complaint or a reported fatality or multiple hospitalizations. Because injury rates have been declining in the last few years, the injury rate cutoff has been lowered. In November 1984, the cutoff was set at 4.2 lost workday cases per 100 employees. This policy might create an incentive to systematically not record all occupational injuries. This problem and the general accuracy of the BLS estimates is discussed below.

BLS Supplementary Data System. To provide more detailed information on occupational injuries and illnesses, BLS began a second data collection system, the Supplementary Data System (SDS). BLS began testing the feasibility of collecting more detailed information as early as 1973, but did not establish uniform reporting formats and definitions until 1976 when the SDS was established in cooperation with 27 states. The SDS is based on the information reported to state workers' compensation agencies by employers or insurance carriers on Employers' First Reports of Injury or Illness. Employers usually provide the information on those reports although they are often submitted to the state agencies by the insurance carriers (Root and McCaffrey, pp. 17-8).

Workers' compensation laws, regulations, and administration differ considerably among the states, especially regarding the minimum number of days of disability before payments to replace lost income will be made. The Supplementary Data System reflects these differences, as well as differences among the states in the type of cases the state reports to the SDS. Some states report only cases that have been fully adjudicated during the reporting year and for which compensation or medical payments have been made. Other states report only cases received from employers during the year that involve more than a minimum number of lost workdays. Still other states report any case that involved either lost work time or a medical payment.

BLS requires that the cooperating states submit certain coded information concerning the incident and the injured employee for each reported case. The required information includes: occupation, industry, the nature of the injury, part of body affected, type of accident and source of injury. States, at their option, may also provide certain other information, including: day, time, age of employee, length of service, wage rate, extent of disability, and the amount of workers' compensation and medical treatment payments.

BLS compiles the coded information and organizes it into three multi-state data files, which may be obtained on computer tape. A series of standard tables for each of the participating states may also be obtained on microfiche from the National Technical Information Service (NTIS).

Work Injury Report Survey Program. The BLS also has conducted more detailed surveys of injured workers identified through First Reports of Injury. BLS, OSHA, and NIOSH jointly determine the research topics, while BLS designs the questionnaire, which participating state agencies administer. The questions cover the circumstances surrounding the injury, employer policies, work and environmental factors, and employee work experience and training. The questionnaires are mailed to the injured employee, who answers it, and returns it to BLS, where the responses are tabulated.

BLS has published results for a number of these surveys. These have included reports on injuries to eyes, faces, heads, feet, hands and arms, and back injuries associated with lifting. (Chapter 8 of Preventing Illness and Injury in the Workplace contains a discussion of the use of personal protective equipment based on information from several of these reports.) In addition, BLS has conducted surveys of injuries in particular industries, or associated with specified types of equipment and work activities. These reports have covered injuries in the oil/gas drilling and servicing industry and the logging industry, as well as injuries associated with ladders, scaffolds, welding and cutting equipment, power saws, equipment servicing, falls from elevations and falls on stairs. Forthcoming reports will study injuries to construction laborers, injuries to warehouse workers, heat burns, and chemical burns.

BLS has begun to ask questions designed to describe the sequence of events, conditions, and circumstances surrounding an injury. This information on the events surrounding injuries, and the other information concerning the severity and the type of injury can be useful for designing preventive countermeasures in the future. Development of more information of this type would enhance the chances for success in reducing the incidence of injuries.

OSHA Fatality/Catastrophe Investigations. OSHA regulations require employers to notify OSHA within 48 hours of any incident that results in the death of one or more employees or hospitalization of five or more employees. OSHA investigates many of these reported accidents. The information contained in these reports has generally only been used to determine whether or not employers should be subject to an OSHA citation for a violation of OSHA's regulations. But these reports might also contain information that is useful for understanding the causes of fatal injuries and for designing preventive countermeasures. The General Accounting Office criticized this in a 1979 report entitled: How Can Workplace Injuries Be Prevented? The Answers May be in OSHA Files.

Even before this report, however, OSHA's Office of Statistical Studies and Analysis had begun a limited effort to collect the reports concerning specific types of accidents and to analyze them. To date, OSHA has prepared reports on fatalities related to fixed machinery; scaffolds; ladders; roofs, ceilings, and floors; oil and gas drilling rigs; miscellaneous working surfaces; fires and explosions; lockout and tagout of equipment; grain handling; and certain types of powered platforms. (For the titles of these reports, see the list of references at the end of this paper.) Several of these reports were prepared to provide information for revisions of OSHA's safety standards.

The collection of accident reports requires some effort because they are not filed in central location, but remain in the OSHA Area Office that conducted the inspection. The analysis of the information on the reports is limited for two basic reasons. First, the reports that are received may not be a representative sample of all the accidents that occur. Second, the information in the reports, although useful, has not been collected to determine the nature of preventive countermeasures. For example, the inspector collects information concerning whether there appeared to be violations of OSHA's regulatory standards. This may provide information on prevention, to the extent that compliance with current OSHA standards would have prevented the fatality. But this may not include information on other changes in the design of workplace equipment, the implementation of work procedures, or the use of personal protective equipment that could prevent future injuries of the same type.

Information on how compliance with current standards can prevent injuries, and information on the preventive potential of other changes, would be useful for developing new OSHA standards, for training OSHA inspectors, for designing new plant and equipment, and for educating workers and managers. Recently, OSHA inspectors in two regions of the country began to prepare one-page descriptions of fatal injuries in the construction industry. Because of all of the potential uses, OSHA should take steps to develop a more complete system of reporting. This could include uniform methods for accident investigation and reporting, as well as the national collection and analysis of this information for all industries. This effort, of course, should be oriented towards developing information useful for prevention.

Other Sources

National Safety Council. The National Safety Council (NSC) is a voluntary association of individuals and organizations interested in promoting safety. It was organized in 1913 and received a Congressional charter in 1953. The Council functions as a forum for safety professionals, disseminates information on injury and illness prevention and advocates accident prevention measures, standards, and laws (NSC, "This is the National Safety Council").

They also publish an annual booklet of information entitled *Accident Facts*, in which they reprint data from other sources and their own estimates of the number of occupational and nonoccupational disabling injuries and deaths. Their estimates for occupational injuries and deaths are based on various sources of information including reports from companies who are members of the NSC, state departments of health, state industrial commissions, insurance companies, and the National Center for Health Statistics.

The National Center fo[illegible]alth Statistics. Several programs of the National Center for Health Statistics (NCHS) provide information useful to assessing the number of occupational injuries and illnesses. First, NCHS tabulates data filed by state vital statistics agencies based on information from death certificates. NCHS does not receive the actual death certificate, but only coded information from the death certificates. Many of the death certificates for accidental deaths have information recorded on the type of accident and its location. The quality of death certificate information is uneven. Especially important for occupational statistics is the fact that the certificate does not always record work-related deaths as such.

The NCHS, in cooperation with the Bureau of the Census, also annually designs and administers the National Health Interview Survey. The survey has collected data on the incidence of acute conditions, limitation of activity, injuries, hospitalizations, disability days, dental visits, physician visits, and the prevalence of selected chronic conditions since 1962. The data are collected in a continuing nationwide, household interview survey. In 1980, approximately 39,000 households with about 103,000 persons were interviewed.

In order to counteract the vagaries and inaccuracies of human memories, the incidence of acute conditions is based only on those reported conditions beginning during the two weeks prior to the interview and that lead to restricted activity or consultation with a health professional during that two-week period. The survey has questions concerning the nature of accidental injuries and whether the person was at work at the time of the accident (NCHS, "Current Estimates from the National Health Interview Survey, 1980, pp. 2, 7).

National Institute for Occupational Safety and Health. Two efforts of the National Institute for Occupational Safety and Health (NIOSH) also provide data on the occupational injury and illness problem. First, between 1972 and 1974 NIOSH collected information in its first National Occupational Hazard Survey (NOHS). This survey was designed to collect information on the number of employees exposed to hazardous substances, as well as the extent of existing controls, and employer use of professional safety, industrial hygiene and medical personnel. Establishments were selected to be representative of U.S. Industry. A total of 5,200 establishments in 67 standard Metropolitan Statistical Areas were selected for the survey. The data were collected over the two year period by a group of trained hazard surveyors who conducted interviews with plant management and then toured the plant premises. The surveyors recorded the types of substances encountered and the number of workers exposed to each. Although workers were categorized between "full-time" exposures (at least 4 hours per day) and "part-time" exposures (less than 4 hours per day), actual exposure levels and durations were not measured or calculated (NIOSH, NOHS). Data collection in a second survey, renamed the National Occupational Exposure Survey (NOES) has recently been completed and are now being compiled and analyzed.

The second NIOSH effort involves injury data. The Consumer Product Safety Commission (CPSC) has for several years collected data concerning accidental injuries associated with consumer products from a sample of emergency room admissions. The system created to collect this data is called the National Electronic Injury Surveillance System (NEISS). Through an agreement between CPSC and NIOSH, this system now also collects information on emergency room admissions for occupational injuries. Data for occupational injuries has been collected since May, 1981.

Social Security Administration. The Social Security Administration (SSA) has sponsored three surveys of disabled and nondisabled adults in 1972, 1974, and 1978. In 1978, they sampled about 10,000 persons. These surveys collect information on family background, work experience, health conditions, attitudes, work limitations, job training, family income, job satisfaction, knowledge of government programs, and disability benefits. Some of these questions provide information that can be used to estimate the prevalence of work-related disability and the adequacy of current income support programs (Shor, pp. 5-6).

Public Employee Statistical Collection. Federal agencies collect data on occupational injuries and illnesses incurred by federal employees. These data are compiled and published by OSHA in Occupational Safety and Health Statistics of the Federal Government. About half the states and territories collect information on state and local employees. These data on state and local employees are not compiled nationally (BLS, Handbook of Labor Statistics, 1980, p. 442). Most of the states, however, who participate in the SDS do report workers' compensation claims for state and local government employees, subject to limitations similar to those for private employment.

Number of Occupational Injuries

Fatalities

Information on the number of occupational fatalities over time is available from two sources——the National Safety Council and the BLS Annual Survey. The NSC has compiled estimates of the number of work-related deaths since 1928, while BLS has done so since 1973.

To compile its estimates, the NSC uses the National Center for Health Statistics tabulations of causes of death from death certificates in conjunction with reports from State registrars of vital statistics that have been compiled through the NSC's Accidental Death Summary reporting system. They compile this information and apportion the deaths into three accident classes: work, home, and public. The factors used to divide the accidents are based on information from a variety of agencies, special studies, and NSC analysis. Table 1 presents the NSC estimates for the number of occupational deaths and occupational death rates from 1933 to the present (NSC, "Documentation," pp. 3-6).

The BLS uses data collected by its Annual Survey to generate its estimates of the number of work-related fatalities. Table 2 presents these estimates. It must be noted that, due to limitations in the size of the survey sample since 1977, the BLS estimates for fatalities in small establishments in any one year are not very reliable. Thus, each year BLS publishes estimates for fatalities in private sector workplaces with 11 or more employees. BLS does calculate a five-year rolling average number of fatalities for establishments with fewer than 11 employees. For the period 1974-78 this average was 900 deaths, while for 1979-84 it was 1,040. The BLS figures exclude deaths that occur to the self-employed, unpaid family members working at family businesses, domestics, and religious personnel.

BLS-NSC Discrepancy. The divergence between the BLS estimates of 3,100 to 4,950 and the NSC estimate of 11,100 to 13,300 for the years 1979 to 1983 has been the source of some discussion and debate. Everyone agrees that the universes covered by the two systems are different. The NSC universe is larger and includes all the groups excluded by the BLS. In 1983, the universe of all private employers covered by BLS employed 74,749,900 employees, while 63,981,000 were employed in establishments with 11 or more employees. NSC, using BLS employment data, estimates its universe at 100,100,000 workers.

According to BLS, the differences in the employment universes does not explain all of the gap between BLS and NSC. Adjusting the BLS estimates to include groups excluded by BLS still leaves the BLS estimate at a level 22-30 percent less than the NSC estimate (See BLS, "Comparison of 1974 NSC and BLS Death Estimates."). BLS argues that this remaining difference can partially be explained by an overstatement of work-related deaths in workers' compensation first reports, which are one source of information used by the NSC (See letter to Senator Harrison Williams, from Julius Shishkin, Commissioner of BLS, April 11, 1975).

A BLS and OSHA study of a group of workers' compensation fatality cases submitted to BLS from 45 States and territories for 1972 provides some information on the possible overstatement of fatalities from these workers' compensation reports. Some of the State submissions included cases from previous years, duplicate reports, and deaths not occupationally-related. Of the 6614 cases submitted by the participating States and territories, the OSHA and BLS researchers rejected 691, or about 10 percent. The BLS and OSHA researchers believed that these nonwork-related deaths and reported deaths that actually occurred in previous years partially explain why the NSC's estimates are higher than those of BLS (OSHA, Div. of Statistical Studies, "Occupational Fatalities").

NSC officials argue, on the other hand, that they do screen reports to eliminate nonwork-related deaths (Al Hoskins, NSC, personal communication). NSC has generally argued that the variety of sources that they use and the cross-checking this allows will yield accurate estimates of the number of accidental deaths.

Other Sources. Besides the BLS Annual Survey data and the estimates of the NSC, four other sources provide limited information on the number of occupational fatalities. These are: Federal agency reports, the workers' compensation system, death certificates, and employer reports to OSHA. For Federal government employees, Federal Agencies reported 108 work-related deaths among civilian personnel to OSHA in 1981 (OSHA, Occupational Safety and Health Statistics of the Federal Government). Ninety-three of these were from injuries and 15 from illnesses. Thirty-eight State and territorial workers' compensation authorities reported the number of deaths compensated in 1979 to the NSC. As compiled by the NSC in Accident Facts, there were 6459 deaths in those 38 States and territories.

NCHS annually compiles information from death certificates. Although this compilation is one of the sources used by NSC for their estimates, it is also worthy of separate attention. For nontransport injuries, NCHS compiles the number of deaths by the place of the injury, although these are not categorized according to whether or not the decedent was "at work." Of the 46,009 death certificates reporting nontransport deaths from physical trauma in 1977, 32,722 had enough information to enable NSC to code the location of the event. 2,977 were located on "farms," "mines and quarries," or "industrial places." It is likely that most of the deaths in these places occurred to people at work. Probably few of the 17,531 deaths coded "home" or the 319 at a "place of recreation" are work-related although there may be some.

Unfortunately, the NCHS statistics by themselves cannot describe the portion of the 11,895 accidental nontransport deaths on "streets and highways," in "public buildings," in "resident institutions," and in "other specified places" that occurred to people at work. In addition, the work-related deaths from the 13,287 death certificates that had no coded location must also be included. Finally, transportation-related deaths occurring to people at work need to be added, including some fraction of motor-vehicle accidents (49,700), water transport accidents (1,357), air transport accidents (1,643), and railway accidents (576) (NCHS, Vital Statistics of the U.S., 1977).

From these totals should be subtracted several causes of death that are relatively unlikely to be related to workplace deaths. In particular, drownings, firearm-related deaths, poisonings by drugs, and deaths from food obstructions are much more likely to be associated with off-the-job activities than with occupational conditions. This adjustment will tend to create a conservative estimate of job-related deaths because, in fact, some drownings and firearm-related deaths are occupational. (See Baker, et al and Tables and below).

Subtracting these fatalities yields an estimated 2,600 deaths on "farms," "mines and quarries," "industrial places," about 15,000 deaths for "home," and "place of recreation," and about 7,000 nontransport deaths in "public buildings," on "streets and highways," in "resident institutions," and in "other specified places." The adjusted total for deaths without a specified location is about 9,400.

To the nearly 2,600 deaths due to injury on "farms," "mines and quarries," or "industrial places," to "persons at work," should be added a small fraction of the deaths coded "home" and "place of recreation." If two percent of these are occupational, then an additional 300 deaths should be added. If ten percent of the over 7,000 deaths in "public buildings," "streets," "institutions," and other places are occupational, that yields another 700 deaths. Thus 3,600 deaths might be occupational of the 24,400 nontransport deaths in identified locations or about fifteen percent. If this same percentage is applied to the approximately 9,400 deaths lacking information on location, then another 1,400 deaths should be added. Thus, based on these assumptions, the total number of nontransport. work-related injury fatalities could be 5,000.

To this must be added work-related deaths involving transportation vehicles. The NSC estimates for 1980 indicate that 4,500 of 13,000 deaths, or about 35 percent were related to motor vehicles. As will be discussed below, about 34 percent of the non-heart attack, work-related deaths, reported to BLS involve motor vehicles and about six percent involved aircraft crashes. Baker, et al, discovered in Maryland that 25 percent of deaths involved on-the-road motor vehicles, 11 percent involved boats, and 5 percent airplanes, yielding a total for transport-related deaths of 41 percent. So, if transport deaths constitute 35-40 percent of occupational fatalities due to injuries, then an additional 2,700 to 3,300 deaths should be added to the nontransport-related total of 5,000. This yields a total of 7,700-8,300.

If the percentage of deaths in public buildings, street, institutions, and other places that are work-related is actually 25 percent, and similar proportions of deaths coded without locations and transport deaths are added, the range could be 10,000-10,800. If, on the other hand, none of the home and recreational area deaths are work-related, only 5 percent of the public building, street, institution and other place deaths are work-related, and only 30 percent of work-related deaths are transport-related, then an estimate of 5,800 deaths can be generated. Thus analysis of the available coded information from death certificates yields estimates of between 5,500 and 11,000 deaths for 1977—a range which is compatible with both the BLS and the NSC estimates.

As mentioned above, OSHA investigates reports of occupational fatalities and accidents that involve hospitalization of five or more employees. A special collection of reports received in 1972 was conducted by OSHA. In that year, only one year after the fatality reporting requirement came into effect, 4150 fatalities were reported (OSHA, Office of Statistical Studies, 1972, p. 10).

OSHA data for Fiscal Year 1982 reveal that Federal OSHA conducted 1,884 of these accident investigations. Of these, 1,485 inspections (79 percent) involved one or more fatalities. The total number of fatalities investigated was 1,566. The OSHA data do not include the total number of reports which they receive from employers, but only those which were actually investigated. In addition, for Fiscal Year 1982, State OSHA programs conducted 4,663 accident investigations. If the proportion of fatality investigations from Federal OSHA (79 percent of all accident inspections involve fatalities), and the average number of deaths per fatality investigation (1.05 deaths/investigation) is applied to the 4,663 inspections by the State programs, then an estimate of 3,870 investigated fatalities can be generated. Adding this to the number of fatalities investigated by Federal OSHA (1,566) yields a total of about 5,440. However, some State programs may investigate a greater number of non-fatal injuries than does Federal OSHA. To the extent that this occurs, this estimate of 5,440 should be reduced.

This estimate compares to the BLS figures of 4,370 and 4,090 for private sector establishments of 11 or more employees, and NSC estimates of 12,100 and 11,100 in calendar years 1981 and 1982. The approximately 1,000 deaths in small establishments (fewer than 11 employees) should be added to the BLS figures, for a total of about 5,100 to 5,400. However, about 11 percent of the BLS estimates involve heart attacks. Subtracting these deaths yields an estimate of 4,500 to 4,800 deaths due to injuries for these two years.

At first glance, this would appear to agree fairly closely with the estimate of the number of fatalities investigated by Federal OSHA and the State programs. However, OSHA and the State programs oftentimes do not investigate occupational fatalities related to transportation (e.g. over-the-road motor vehicles, airplanes, boats). As is discussed below, these deaths can account for 30 to 40 percent of the deaths reported to the BLS Annual Survey. If it is assumed that none of these are investigated by OSHA, then an adjustment to account for the transportation-related injuries might add 2,300 to 3,600 deaths to the estimate of 5,440. This would yield an estimate of 7,700 to 9,000. However, to the extent that transportation-related deaths are investigated, this estimate should be adjusted downwards.

Two studies by Susan Baker and colleagues reveal the underlying weakness of nearly all the available data sources. Karlson and Baker (1978), in an intensive examination of occupational deaths in Wisconsin for 1976, found that 76 percent of the deaths could be identified as workplace-related from death certificates alone and only 57 percent from workers' compensation records. Even fewer, only 35 percent of the deaths, had been reported to OSHA. Similarly, in a study by Baker et al (1983), of 148 fatalities in Maryland, they found that each of three sources---workers' compensation claims, reports to Maryland OSHA, and death certificate listings---did not reveal more than two-thirds of all the cases eventually identified as work-related. Another State office, the Office of the Chief Medical Examiner, which examines every death due to injury in Maryland, did have records for 96 percent of the cases (Baker, et al., p. 692).

OTA Estimate. As discussed above, for the last five years, the BLS figures for occupational deaths in private sector establishments with 11 or more employees range between 3,000 and 5,000, while about 1,000 occur in private sector establishments with fewer than 11 employees. The NSC figures range between 11,000 and 13,500 for the entire workforce. NCHS data, based on death certificates, are insufficient to resolve the difference between BLS and NSC. Applying a variety of assumptions to the death certificate data yields a range of estimates from 5,500 to 11,000 for the entire workforce for 1977. OSHA inspection data suggest a possible range of 4,500 to 9,000 for the private sector workforce in Fiscal Year 1982, although the upper end of this range is very dependent on assumptions concerning the number of occupational fatalities that are not investigated by OSHA.

The best source of statistical information on occupational fatalities are the Annual Surveys conducted by the BLS. They use a large survey sample that is capable of directly measuring the occurrence of injuries. However, because this sample covers only private sector employment (the self-employed and public sector employees are excluded), an adjustment must be made to generate an estimate of the number of deaths due to injury for the entire workforce.

OTA used two similar methods to develop its estimate. The first estimate is based on the 5-year average of the number of fatalities in establishments with 11 or more employees. For 1979 to 1983, this equals about 4,180. To this should be added the 5-year average from the BLS Annual survey of deaths in establishments with fewer than 11 employees. For 1979 to 1983, this was 1,040. Approximately 11 percent of these are due to heart attacks. Subtracting these yields a total of 4,650 deaths due to injury. To this should be added the deaths among the self-employed and public employees. Applying the death rates for private sector workers (see Table 2), adjusted for heart attacks, to the portion of the workforce not covered by the BLS data, yields a range of 1,300 to 1,870 deaths with an average of 1,640. Adding this to the 4,650 generated directly by the Annual Survey yields a total of about 6,300 deaths.

Alternatively, the BLS figures for establishments with 11 or more employees for each year (see Table 2) can be adjusted by applying the death rate (for injuries) to the entire group that are either excluded completely (self employed and public employees) or for which annual estimates are not available (small, private sector establishments). Using this method, the total ranges from 7,265 in 1979 to 4,600 in 1983, for an average of 6,180 deaths.

Rounding either of these estimates to the nearest thousand yields OTA's estimate that about 6,000 deaths due to occupational injuries occur each year. These deaths translate into about 25 deaths per day. But because most occupational fatalities occur in groups of one or two, these deaths rarely receive significant publicity. (The topic of fatality rates and trends in those rates is taken up in a later section of this paper.)

Nonfatal Workplace Injuries

National Safety Council. The NSC estimates the number of work-related disabling injuries, which they define as injuries that "result in death, some degree of permanent impairment, or render the injured person unable to effectively perform his regular duties or activities for a full day beyond the day of the injury." Because disabling injuries, defined, are not reported on a national basis, the NSC approximates the number of such injuries using ratios of disabling injuries to deaths from special studies (NSC, *Accident Facts*, pp. 2-3).

Table 3 presents the NSC estimates for 1945 through 1983. These estimates have remained fairly constant over time. This indicates that either workplace injury rates have improved at a rate exactly equal to the rate of increase in the size of the labor force or that the NSC estimation method is relatively insensitive to changes over time. For 1983, NSC estimated 1.9 million on-the-job disabling injuries.

BLS. Responses collected from the BLS Annual Survey are used to develop estimates of the number of "recordable injuries," (see discussion above) including lost workday cases and nonfatal cases without lost workdays for private employers. The BLS estimates for both occupational injuries and occupational illnesses are published annually. As is discussed below, the BLS methodology can be expected to miss most chronic occupational illnesses as well as other illnesses for which the occupational connection is not clear. Table 4 presents the BLS injury estimates and Table 5 the illness estimates. For 1983 they estimated that there were about 4.7 million total recordable injuries, of which about 2.1 million involved lost workdays. For illnesses, they estimated about 105,000 recordable cases and 42,000 lost workday cases.

Federal Employees. Data collected by Federal Agencies on occupational injuries and illness occurring to their own employees are compiled and published by OSHA. The definitions used are identical to those used for private employers. Table 6 presents injury and illness information for Federal civilian employees. In 1982, about 164,000 total recordable injuries were incurred by civilian employees. Of these, about 84,000 injuries resulted in lost workdays.

Workers' Compensation Cases. The Office of the Assistant Secretary for Policy, Evaluation, and Research (ASPER) of the Department of Labor, has estimated that in 1978 there were about 7.8 million workers' compensation awards. Six million of these were for medical payments. The 1.8 million disability awards broke down to 1.3 million for temporary disability and 418,000 for permanent partial disability. Finally, they estimate that there were 2,600 awards for permanent total disability and 7,800 awards for death benefits (ASPER, p. 65).

State and Local Government Employees. No national statistics on occupational injuries and illnesses for State and local government employees are compiled. It is possible, however, to generate an estimate from information reported to the BLS Supplementary Data System. For the 30 States and 1 territory that report workers' compensation claims for both private and public sector employers in 1980, the public sector (both State and local government) claims represented, on average, 12.1 percent of the total claims from both public and private employment. If this same proportion applies to total recordable cases and lost workday cases in all States in 1983, this would imply that State and local government employees incurred about 575,000 recordable injuries in 1983, of which about 259,000 involved lost workdays.

National Health Interview Survey. The National Health Interview Survey (HIS) also provides information on the number of persons injured at work, although the methods and definitions used by this survey differ from those of BLS. The two systems differ also in that HIS interviews individuals in a household survey (about 39,000 households with about 107,000 persons), while BLS administers a mail survey to about 280,000 business establishments.

Injuries are defined as any condition classified under nature of injury code numbers 800-999 of the International Classification of Diseases. Injuries are included in the survey reports only if they are "medically attended" or involve a "restriction" of activity.

"Medically attended" is defined as consulting a physician about the injury either at its onset or at any time thereafter, although there must have been at least one consultation before the end of the two-week interview period. Medical attention includes office visits, consultation over the telephone, and physician advice transmitted through a nurse. "Restricted activity" days are ones on which a person cuts down his or her usual activities for the whole of the day because of an illness or injury. It, of course, includes "bed disability" days and "work-loss" days. "Bed disability" days are ones during which a person stays in bed all or most of the day and includes all days of hospitalization. "Work-loss" days are days on which a person did not work at his/her job or business for at least half of the normal workday (NCHS, *Current Estimates*, 1980, pp. 50-1).

Table 7 presents estimates of the total number of persons injured in work accidents and the number of restricted activity and bed disability days associated with those injuries estimated by the National Health Interview Survey. The total, in 1981, of 11.3 million persons injured is considerably higher than the 5.3 million total cases recorded in the 1981 BLS Annual Survey. This is partly because the HIS interview results are extrapolated to estimate the number of injuries among 99.2 million "currently employed" individuals, while the BLS survey covers only the 75.0 million employed by private sector employers. As described above, the BLS survey excludes the self-employed, farm operations with fewer than 11 employees, and Federal, State, and local government agencies.

According to data from 1977-79, on average about 23 percent of the work injuries reported to the NHIS result in bed disability, while an additional 37 percent, although not bed disabling, restrict activity. The remainder, approximately 41 percent, were medically attended but did not lead to "restricted activity or "bed disability."

Table 8 presents data for the four different classes of accidents defined by the NHIS. In 1980, the number of people injured at work accounted for about one-sixth of all injuries. Work injuries are, in general, more severe than the average for all classes of accidents. On average, work injuries are associated with 3.94 days of bed disability and 17.05 days of restricted activity per injury, while the averages for all accidents are 2.84 bed disability days and 11.44 restricted activity days.

In 1976, NCHS published a special analysis of the data from the the 1971 and 1972 surveys of injuries from all classes of accidents. In those two years, the nation averaged 8,785,000 work injuries per year. Those accidents accounted for 111,317,000 days of restricted activity, including 27,127,000 days of bed disability and 36,474,000 lost work days (NCHS, *Persons Injured and Disability Days*, pp. 8, 27). Thus there is about one reported lost workday for every three days of restricted activity and about 1 1/3 lost workdays for each day of bed disability.

NCHS has not published lost workday information separately for work injuries since the analysis of the 1971-72 survey. But if it is assumed that the ratios of lost workdays to restricted activity days and bed disability days have remained the same, estimates for 1981 can be generated. The lost workday to day of restricted activity ratio of .33 times 214.9 million days of restricted activity in 1981 yields an estimate of 70.9 million lost workdays. The lost workday to bed disability day ratio of 1.34 times 44.0 million bed disability days in 1981 yields an estimate of 58.9 to 70.9 million lost workdays compared to the 39.2 million estimated by the BLS Annual Survey.

National Electronic Injury Surveillance System. The National Electronic Injury Surveillance System also provides an estimate of the number of workplace injuries treated in emergency rooms. Using a sample of 66 cooperating hospital emergency rooms, NIOSH estimates that during the first nine months of 1983, approximately 2.4 million patients with occupational injuries were treated in emergency rooms. About three fourths (1.83 million) of these were males (Morbidity and Mortality Weekly Report, February 25, 1983. p. 9). An extrapolation of the nine month total to a 12-month total yields an estimate 3.2 million emergency room cases per year.

Distribution of Injuries and Illnesses

Occupational Fatalities

The distribution of employment and fatal occupational injuries by industries is shown in Table 9. The 4,400 fatalities in 1980 were not evenly distributed among industries. For example, mining with only 2 percent of employment, accounted for 10 percent of the fatalities. Similarly, construction with 5 percent of employment accounts for 19 percent of reported on the job deaths. On the other hand, the wholesale and retail trades represent 23 percent of employment, but incurred only 13 percent of the fatalities. Finance, insurance, and real estate, along with the service industries accounted for 29 percent of employment, but only 11 percent of fatalities.

Tables 10 and 11, from the BLS Annual Surveys of 1979 and 1980, and Table 12 from a recent article by Susan Baker and colleagues, show the distribution of fatalities by industry and cause. The survey data of BLS and the detailed search of medical examiner and death certificate information by Baker, et al, reveal similar patterns. Motor vehicles are the largest single cause of occupational fatalities reported in both data sets. The proportion of motor vehicle deaths varies among the various industries, ranging from 16-18 percent in construction and manufacturing to about half of all fatalities in transportation and utilities; trade; and finance, insurance, and real estate.

Heart attacks in the BLS data (11 percent) are those that occur while the person is at work. Although exposures to some substances can cause acute myocardial infarction and some chronic occupational illnesses may lead to heart failure, many of the heart attacks that occur while on the job may not have been caused by workplace factors. On the other hand, some off-the-job heart attacks may have been caused by occupational factors. Baker, et al (198[illegible] [illegible]died only deaths due to injury and so no deaths from heart attacks ap[illegible] on Table 12.

Fatal injuries involving nonroad or industrial vehicles, including forklifts, tractors, bulldozers, and backhoes are the most common cause of death following over the road vehicles and heart attacks. The two sources diverge slightly after this. Baker found shootings to account for 11 percent of fatal occupational injuries, while BLS reports 4 percent. This might be due to the differing scopes of the two sources. Baker covers all employment including police officers and the self-employed. The latter group included several gas station owners, and taxi drivers killed during hold-ups. BLS excludes both public employees and the self-employed. The boat accident total in the Baker study is influenced disproportionately by one accident in which 11 members of a Coast Guard boat crew were killed. Then come falls, aircraft crashes, and accidents with fixed machinery. BLS rounds out its list with falls, electrocutions, aircraft crashes, struck-by injuries, plant machinery, caught-in-and-between injuries, fires, explosions, and gas inhalations.

Nonfatal Occupational Injuries and Illnesses

Table 13 presents the distribution of the number of recordable and lost workday cases and the injury and illness incidence rates by industry division as reported by the BLS Annual Survey. As shown in the table, injury and illness rates vary from industry to industry. Mining; construction; manufacturing; agriculture, forestry and fishing; and transportation/public utilities are more hazardous than the private sector average. The precise numerical ranking of these industries depends on severity—construction has the highest total case rate, but mining has the highest incidence of lost workdays.

Table 14 present incidence rates by size of establishment. Overall, the lowest average rates are those for the very smallest and the very largest establishments with the medium sized establishments having the highest rates.

When plotted on graph paper using injury rates on the vertical axis and establishment size on the horizontal, the resulting shape resembles an inverted letter "u." This relationship is found across most industry divisions and over time. It also appears to confirm the loss experience of the workers' compensation insurance compensation industry.

There are several possible explanations for this "inverted-u" relationship. The first is that large establishments have lower rates because they have more in-house expertise and because, under various "merit rating" plans available to them under workers' compensation, they have the largest incentive to control injuries. Smaller establishments lack both this safety expertise and a financial incentive under workers' compensation.

The smallest establishments might be safer because the owners are working alongside the workers and are thus more "concerned" about safety. It could also be that the span of control or the number of workers supervised by a manager is smaller in small establishments. Thus workplace conditions are under more immediate and direct manager control.

It could also be that small establishments simply don't use the kinds of powered machinery and other technologies that are inherently more hazardous. Larger plants use this technology, but have lower injury rates because of their safety expertise and financial incentives. Medium-sized plants lack all of these features (expertise, financial incentives, or inherently safe technology) and thus, have the highest injury rates.

It could also be that the "inverted-u" relationship is simply due to underreporting of injuries from small plants. This could be because in small, predominantly non-unionized plants, workers may be hesitant to report injuries and may feel compelled not to miss any worktime. Or it could be that small employers are less thorough about keeping records of occupational injuries. In fact, if the data from Table 14 are plotted on graph paper, the points for the categories of 100-249 employees to the largest size trace nearly a straight line. Extending that line for the categories with less than 100 employees would imply injury rates between 12.0 and 12.3. It cannot be determined with certainty that this is the case, but as is noted elsewhere in this working paper, underreporting by small establishments might explain the difference between the estimates of the BLS Annual Survey and the NCHS National Health Interview Survey.

Tables 15 through 18 present distributions of workers' compensation cases from the SDS for 1980. Each table provides information separately for the States that provide information only for cases involving disability days (Disability States) and States that also provide information for cases that involve only medical treatment in addition to disability cases (Medical Treatment States).

Table 15 presents the distributions for the source of injury, which is defined as the object, substance, or bodily motion that directly produced or inflicted the injury. It also presents information from a relatively new classification, the associated object or substance (AOS). This is defined as as the object, substance, or person with respect to which measures could have been introduced to prevent the accident or mitigate the injury or illness.

An example will make the distinction clearer. Say a worker trips over some boxes and falls against a boiler suffering severe burns. The source of injury for this incident is the boiler because it was the object that directly inflicted the injury. But the injury could have been prevented by moving the boxes, so "boxes" would be coded as the associated object or substance.

Table 16 presents the types of accident or exposures. In order, the most frequent types are 1) overexertions; 2) accidents in which an employee is struck by an object; 3) falls, both on the same level and from elevations; 4) accidents in which an employee is struck against something; 5) bodily reactions, and 6) incidents in which the employee is caught in, under, or between machinery or objects.

Table 17 lists the nature of injury or illness. The largest categories are sprains, and strains; cuts, laceration, and punctures; contusions and fractures. An examination of this table reveals that very few workers' compensation cases invole occupational illnesses.

The part of body affected by the injury or illness is listed in Table 18. Three subcategories are presented in addition to the main categories. For head injuries, the number and percentage of eye injuries are presented; for upper extremities, the number and percentage of finger injuries; and for trunk injuries, the corresponding figures for back injuries. Most of the differences between the percentage distributions for the disability and medical treatment cases can be explained by differences in these three categories. Medical treatment cases involve proportionately greater numbers of eye and finger injuries; back injuries are more commonly found among disability cases.

Published Analyses Using SDS Data

It is possible to make national estimates of the number of injuries for the various SDS categories. For example, David McCaffrey has estimated, using the data of the SDS and the BLS Annual Survey, that in 1977 approximately 21,000 amputations occurred in U.S. workplaces. OSHA, in a study of conveyor-related injuries, estimated using SDS data, that approximately 17,000 conveyor-related lost workday injuries occurred in 1976 (OSHA, 1980). Both McCaffrey and OSHA further analyzed amputations and conveyor injuries by examining the distribution of these injuries among industries, sources of injury, and types of accidents.

The staff of the Office of Occupational Safety and Health Statistics in the Bureau of Labor Statistics have published several analyses using SDS data that reveal interesting aspects of the distribution of occupational injuries and show some of the uses for these data. Using information from the SDS, BLS staff have been able to calculate the percentage of injuries accounted for by various standard occupational classifications. Using other BLS data on employment, it is possible to determine the percentage of employment in each classification. Dividing the percentage of injuries by the percentage of employment for each occupational category creates an index that can be used to determine what occupations have the highest risk of injury.

Calculating this index for 1978 SDS data revealed, not surprisingly, that blue-collar workers have a higher risk of on-the-job injuries than white collar workers. But more interestingly, the BLS index can be used to pinpoint various occupations, by industry, that are at high-risk of injury. For example, the following occupations have an index of 2 or more (implying that each occupational classification has more than twice the average level of risk): carpenters, millwrights, roofers, sheetmetal workers, meat cutters and butchers, welders and flame cutters, machine operators, truck drivers, construction laborers, freight and material handlers, and warehouse laborers. (Root and Sebastian, 1981).

Three other studies of SDS data examined the influence of job experience on injury rates, the relative injury rates of younger and older workers, and the injury experience of women workers. The "new worker" factor as an explanation of higher injury rates has been cited for some time and one BLS study (Root & Hoefer, 1979) confirms it. They found, using SDS data for 1976 and 1977, that a total of 42.5 percent of injuries occur to workers who have been on the job less than one year. In fact, nearly 22 percent of injuries occur to workers on the job three months or less (Root and Hoefer, 1979, p. 77).

Researchers have not been united on the relationship between age and workplace injury rates. Some have argued that there are no significant differences among age groups. Some have found that younger and older groups were at higher risk, while others concluded that younger and older workers were at less risk than those in the middle. Still others found that risk declined steadily with increasing age. Using SDS data, Norman Root (1981) calculated frequency ratios between the percentage of injuries and percentage of employment by age group. The highest ratios were found for workers aged 20-24. Workers aged from 18-19 rated second, and then, in order, were 25-34 year olds, and 35-44 year olds. Forty five to 54 year olds and 55-64 year olds had the same ratios. Even though younger workers face a higher risk of injury, their injuries tend to be temporary disabilities. Older workers suffer a proportionately greater number of fatalities, and permanent disabilities.

Finally, Root and Daley (1980), have used SDS data to determine whether women are safer workers than men. Although women comprised about 41 percent of the work force in 25 states reporting to SDS in 1977, they incurred only 21 percent of the injuries. Using SDS data, they were able to conclude that women have lower injury rates because they tend to work in lower risk occupations. In other words, men and women in the same occupations tend to have similar injury rates. There were two "noteworthy exceptions" to this, however. Women tended to incur relatively more "falls on the same level" than men and tend to experience relatively more cases of inflammation of joints, tendons, and muscles (Root and Daley 1980).

Thus the SDS can be used for several purposes and can provide answers for some questions concerning the nature and distribution of occupational injuries. There are significant limitations, however. First is that this kind of aggregated analysis of injury data does not provide any conclusive answers concerning the kinds of interventions that would prevent these injuries. For example, it is clear that younger workers and inexperienced workers are at higher risk, but is this because they are young and new to the job, or because they have the least seniority and are assigned to the less desirable, more hazardous jobs? Moreover, what kind of training programs or what kinds of equipment/workplace redesign would reduce those injury rates? The SDS cannot answer these questions. But even without providing conclusive answers, it can serve to generate hypotheses and serve as a base for more detailed research.

In addition there are two limitations inherent in the current data collection effort that may limit the usefulness of analysis of SDS data. First, not all of the states and territories submit data to SDS and second, several states report only cases that involve a minimum number of days of lost worktime. This may make the SDS data unrepresentative for certain uses. One improvement might be to require all states to participate and to standardize the kinds of cases submitted. Alternatively, the Federal government could increase the share of costs that it pays (currently 50 percent) to encourage the nonparticipating states to join.

Injury Trends and OSHA's Impact

Description of Trends

Nonfatal Injuries. The appreciable increase in occupational injury frequency rates during the 1960's was noted many times during the debates concerning passage of the OSH Act in 1970. Figure 1 presents the disabling injury rates from the BLS survey of manufacturing for the decade before OSHA was created. This figure shows rising injury rates, especially from 1963 to 1970. Ideally a comparison of injury rates both before and after the creation of OSHA would provide a measure of the agency's effectiveness. Unfortunately, the definitions of injuries, the BLS survey procedures and the universe of covered workers all changed in 1971 when OSHA was established. Thus it is difficult to make a direct before and after comparison using BLS data.

Table 19 presents injury and illness incidence rates for the private sector employers covered by the BLS Annual Survey from 1972 to 1983. As has been noted, the illnesses included here are predominantly acute illnesses and constitute a very small portion of the total of injuries and illnesses. Figure 2 presents the rates for injuries alone in terms of total cases, lost workday cases, and non-fatal cases without lost workdays. This figure reveals declines in the total case rate from 1973 to 1975 and from 1979 to 1983. The rate for non-fatal cases without lost workdays has declined continuously from 1973 to 1982, although the decline after 1975 is more gradual than that from 1973 to 1975. The lost workday rate has, on the other hand, generally increased over the period, with declines only from 1974 to 1975 and from 1979 to 1982.

The NSC does not itself compute rates for disabling injuries, but these rates can be computed using the NSC estimates of the worker population (Table 1). The resulting rates are shown on Table 3. From 1950 to 1960, the disabling injury rate declined from 3.5 per 100 workers to 3.0, a drop of about 14 percent. From 1960 to 1970, the decline was about 7 percent. From 1970 to 1980 the overall decline was about 18 percent, despite rising rates from 1969 to 1972. However, the declines in the NSC data are not reflected in BLS data. In fact, during the 1960's, the BLS Surveys of manufacturing (the only industries then covered) showed rising injury rates (see Figure 1). During the 1970s, the BLS lost workday case rate, which is the rate most directly comparable to the NSC disabling injury rate, was generally rising, declining only from 1973 to 1975 and from 1979 to 1982 (Table 19). The inconsistency between the NSC trends and the BLS data for the 1960's and 1970's urges caution in the use of the NSC data to describe injury trends.

Rates calculated from the National Health Interview Survey of NHIS do not show any continuing trend from 1962 to 1981. Although there are ups and downs, nearly all of the observed rates fall in a range from 10 to 13 cases per 100 employed persons (see Table 23). Because the relative standard error of the NHIS estimates is approximately 6.6 percent, most of these year to year variations could be due simply to sampling errors and not to any real changes.

Fatalities. For fatal occupational injuries, the data of the NSC generally show declining fatality rates from 1937 to today (Table 1). The decline, however, has not occurred at the same rate over this period. From 1940 to 1950 the fatality rate declined about 29 percent, from 38 per 100,000 to 27 per 100,000 workers. From 1950 to 1960 the decline was about 22 percent while in the sixties the decline was 14 percent. The decline from 1970, the year of the passage of the OSHA Act, to 1980 was 28 percent.

The BLS has collected nationwide information for a shorter period of time (Table 2). Figure 3 presents the trend in these fatality rates. Although these rates have not declined continuously since 1973, the general trend has been downward. The fatality rate in establishments with 11 or more employees has declined from 9.8 per 100,000 workers in 1974 to 7.4 per 100,000 workers in 1982. This is equal to a decline of about 24 percent over a period of 8 years.

The largest single year-to-year change was between 1982 and 1983 when the fatality rate fell nearly 25 percent from 7.4 per 100,000 to 5.6 per 100,000. As is discussed below, this particular decline may be misleadingly large. Overall, the decline from 1974 to 1983 is about 43 percent over 9 years.

Factors That Influence Injury Rate Trends

The declines during the 1970s in the rates for non-fatal cases and total cases have been cited as indications of OSHA's effectiveness, while the rise in the lost workday case rate over the same period has been used to claim that OSHA has been ineffective in its mission of ensuring employee safety. More recently, it has been suggested that the recent declines (1979 to 1983) in the BLS injury rates are an indication that the policies of the current OSHA administration are more effective than past policies (see, e.g., OSHA, press release, Nov. 4 and Nov. 9, 1983).

It must first be noted that the effectiveness or ineffectiveness of OSHA also depends on how well employers carry out their legal responsibilities to safeguard the health and safety of their employees. But beyond efforts of employers and OSHA, several factors confound the injury rate picture and make simple trend analysis misleading.

The first and most important factor is the effect of the business cycle. Other things being equal, increased business activity leads to higher injury rates and decreased activity leads to lower rates. (The effects of the business cycle on occupational injury rates is discussed in greater detail below.)

Second, besides the birth of OSHA, during the 1970's there were also changes in the workers' compensation programs in a number of states. Many of these were in response to the recommendations of the National Commission on State Workmens' Compensation Laws, a body that had also been created by Congress in the OSH Act. Those changes have generally raised benefit levels (generally to a level equal to 2/3 the pre-injury wage level, up to a maximum ceiling amount) and decreased the number of days after the injury that the employee must wait before receiving compensation for lost wages. It has been suggested that one effect of these changes has been increases in the number of reported injuries (see e.g. Chelius, 1982). Moreover, at the same time that benefit levels changed, the administrative mechanisms of state workers' compensation system were often improved. In addition, over time there has also been an increasing recognition of the occupational causes of illnesses, cumulative trauma, and musculoskeletal injuries.

Third, during the 1970's there were also increases in medical malpractice lawsuits. In this situation, doctors and employers may have become more hesitant about sending a worker back to work shortly after an injury. Finally, the increase in the number of two-earner households and cultural changes that are more tolerant towards persons recuperating from injury may have changed the length of time spent in recovering from occupational injuries. The net effect of improved workers' compensation benefits, enhanced administration, increasing recognition, potentially more stable household incomes and changing cultural conditions may be increases in the number of reported injuries.

Injury Rate Trends, the Business Cycle, and OSHA Policies

The current administration, which took office in 1981, has changed a number of aspects of the operations of OSHA. It has been claimed that the declines in occupational injury rates for 1981 and 1982 represent the benefits of this administration's "cooperative, non-adversary approach to job safety and health." (OSHA, press release, November 4, 1983). This claim merits careful examination.

First, as Figure 2 shows, the decline in injury rates began after 1979, two years before the current administration took office. Moreover, the installation of controls, changes in employee training, etc., often take place over several years. Thus it is possible that the observed changes from 1979 to 1983 represent, in part, the effects of past OSHA policies. Second, the changed policy concerning inspection targeting may result in changes in employer recordkeeping concerning injuries. In the absence of independent verification of employer injury records, these recordkeeping changes may hinder efforts to assess the results of the new policies. Third, as discussed above, a number of factors besides the effectiveness of OSHA can influence injury rate trends. Foremost among these is the business cycle.

Since the 1930's researchers have noted the effect of the business cycle on injury rates. The general explanation for this phenomenon is that as business picks up, employers hire more young and inexperienced workers. Both young workers and inexperienced workers of all ages tend to have higher injury rates than older and more experienced workers. Moreover, as production expands, businesses open new plants and bring on line new machinery. For both of these cases there will be a period of adjustment as management and workers learn how to use the machinery safely. In addition, during a business upturn there will be increases in the pace of production, and increases in the amount of overtime worked, less down time, and less time devoted to repair and maintenance, all of which lead to increases in accidents. During business downturns, all of these elements are reversed—younger and less experienced workers are laid off while older and more experienced workers are retained, plant operations slow down, and more effort is devoted to repair and maintenance (Kossoris, 1938; Smith, 1972).

This can be illustrated with several figures. The Federal Government collects and publishes a variety of statistics that measure aspects of the business cycle. The most commonly used of these is the unemployment rate. Figure 4 presents the manufacturing injury rate and the total national unemployment rate for 1958 to 1970. In particular, the rising injury rates from 1963 to 1969 occurred at the same time as declining national unemployment rates.

To make this relationship clearer, in Figure 5 the injury and unemployment rates are plotted together. The horizontal (or x-axis) measures the unemployment rate, while the vertical (or y-axis) measures the corresponding injury rates for the years 1958 to 1970. An examination of this figure reveals that the points for every year except 1970 trace a relatively straight line. This tends to support the view that injury and unemployment rates are associated. Based on these data, it has been estimated that a one percent decrease in unemployment will lead to a .25 percent rise in the work-injury rate (Gorham, 1979). (The point for 1970 does not fit this apparent line. One possibility is that the attention generated by the discussions leading up to the OSH Act somehow altered either data collection efforts or the injury rate - unemployment rate relationship.)

Figure 6 shows data for the BLS total case rate and the unemployment rate for 1972 to 1983. The declines in the total injury rate from 1973 to 1975 and from 1979 to 1982 occurred simultaneously with rising unemployment rates. In addition, the rising injury rates from 1975 to 1979 coincided with declining unemployment rates. In Figure 7, these two variables have been plotted against each other. Again there appears to be a linear relationship, although the points are not as close to a single straight line as were the data for 1958 to 1969.

Finally, Figures 8 and 9 present the rates for lost workday cases and unemployment. In Figure 9, the points seem to break into three groups. Seven points in the center appear to trace a single line, while three points appear to be the left and below this line, and two appear to the right and above this line. The seven center points represent the years 1975 through 1981. The three points to the left and below are for 1972 through 1974, while the two points to the right and above are for 1982 and 1983.

The lost workday case rate may be sensitive to changes in workers' compensation, especially concerning the minimum waiting periods before compensation for lost wages is awarded. Many of the states made such changes in the early to mid-seventies. Thus the points for 1972 to 1974 may represent the injury rate - unemployment relationship prior to the implementation of these changes. In effect, Figure 9 implies that there have been at least two different lines tracing the injury rate - unemployment relationship since the creation of OSHA.

The data points for 1982 and 1983 appear to be above the line for 1975 through 1981 in Figure 9. This could mean that the injury rate - unemployment relationship has shifted again, upwards and to the right. This would imply a worsening of this relationship because any given unemployment rate would be associated with a higher lost workday injury rate.

Based on these figures, it appears that a very large portion of the changes in injury rates over the past twelve years is associated with the business cycle. A more complete analysis would also consider the possible effects of other variables and would attempt to correlate injury rate changes with other measures of the business cycle. Any such analysis, however, will be hampered because there are only eleven data points. Efforts to assess OSHA and changes in OSHA policy would be greatly enhanced if, for example, the national injury rates were available quarterly, rather than only annually.

OSHA has suggested to OTA that the injury rate declines are not the result of the current recession because "BLS has estimated that only 16 percent of the decline in injury rates in 1982 can be attributed to a disproportionate drop in hours worked in high-risk industries." (Auchter, letter). BLS, however, noted that the procedure they used for this calculation, "does not take into account ... other factors which may also affect the rates, but which have not been measured, such as the demographic composition of the workforce, worker education, improved safety measures, the role of State and Federal agency compliance programs, technological change, etc." (BLS, press release, Nov. 4, 1983).

But the "demographic composition of the workforce," and "technological change" are two variables that are very much affected by the business cycle. In addition, the amount of overtime worked, the pace of production, and the rate of new hires are affected by the business cycle. The BLS procedure for calculating the effects of the decline in hours worked in 1982 may not fully capture the effects of these other variables on injury rates.

It has also been suggested that the recent declines in injury rates are not related to the recession because they do not correlate with changes in total national employment (see Figure 10). Changes in employment represent another possible measure of the business cycle, but must be used cautiously because it includes employment in industries with relatively low injury rates. This is particularly important for the years 1979 to 1982, when there were shifts in employment from construction and manufacturing, to the trade and service industries. For example, during those years employment in the relatively more hazardous construction and manufacturing industries has declined while employment in all other industries has increased. Together, construction and manufacturing account for about 70 percent of the injuries reported to the BLS Annual Survey.

Figure 11 presents the lost-workday injury rate for the construction industry plotted with employment in construction. Figure 12 presents the lost-workday injury rate for manufacturing with manufacturing employment. In both cases, the overall picture is the expected relationship: as employment increases, injury rates increase.

However, additional factors may also enter this relationship. For manufacturing the three points for 1972 through 1974 are excluded from Figure 13. In Figure 12, these three points appear below and to the right of the main relationship. Excluding these points clarifies the linear relationship between employment and injury rates. As was discussed above, changes in the law and administration of workers' compensation, improved recognition of occupational causation, increased concern about medical malpractice, the increase in the number of two-earner households, and changing cultural conditions, might explain why there appear to be two different injury rate - employment relationships in Figure 12.

In Figure 11, three different injury rates are associated with employment of 3.9 million in the construction industry. In 1977, the lost-workday injury rate was 5.8 per 100 workers; in 1982 it was 6.0; and in 1983 it was 6.2. This implies a worsening in the injury rate - employment relationship in the construction industry, although it is not clear what changes over this time could have led to this.

Figure 14 presents the fatality rates from 1974 to 1983 plotted with the corresponding unemployment rates. These points do not plot as clear a relationship as the rates for all injuries and lost-workday injuries. In part this is because occupational fatalities are much less common than non-fatal injuries. Because of the relative rarity of fatalities, random year-to-year fluctuations and the random error present in the BLS estimates are larger for fatalities than for all injuries and lost-workday injuries. These fluctuations and random errors may obscure trends and the relationship to other causal factors.

After allowing for this, Figure 14 does appear to confirm the inverse relationship between unemployment and fatality rates that has been observed for non-fatal injuries. However, two points, those for 1975 and 1982, lie above the apparent linear relationship. These may be due to the random fluctuations that can be expected in occupational fatality rates.

Thus the large 25 percent decline between 1982 and 1983 may not represent a real change in working conditions. Instead it could be largely due to the effects of the recession over the entire time period from 1979 to 1983 combined with random fluctuations. In fact, from 1981 to 1982 the decline in fatality rates was less than 3 percent. The decline from 1979 to 1983 amounts to a fall of nearly 35 percent, an average of between 8 and 9 percent per year. Over the same years, the civilian unemployment rate increased from 5.8 percent of the labor force to 9.6 percent.

Thus OTA concludes that the effects of the recent recession, and not changes in OSHA policies, are the most important single factor behind the injury and fatality rate declines from 1979 to 1983. Moreover, the business cycle appears to be the largest single factor behind the changes in injury and fatality rates between 1972 and 1983.

Studies on the Impact of OSHA on Injury Rates

In the Congressional debates concerning the OSH Act, Congressman Steiger expressed the hope that the Act would lead to an injury reduction of 50 percent (quoted in Zeckhauser & Nichols, 1978). A reduction of that size has not occurred. As discussed above, analysis of injury rate trends since the creation of OSHA is difficult, but it is hard to find any large changes in national, aggregated injury rates that do not appear to be associated with the effects of the business cycle.

A number of researchers have conducted statistical analyses of the possible effectiveness of OSHA in reducing occupational injury rates. Because of their greater detail, these studies can provide more information than a simple analysis of trends. But when conducting these studies, researchers must try to correct for other factors that may influence the number of injuries and injury rates. Some of these factors include the kind of industry, the effects of the business cycle, the pace of production and overtime worked, the demographics of the work force (including age, experience, and family income), changes in the administration of workers' compensation, changes in the practice of medicine, and variations in the mix of industries and occupations.

Besides the more general variables that influence injury rate trends, several factors make the task of discovering an "OSHA effect" difficult. First is the size and distribution of the OSHA effort itself. The number of Federal OSHA inspections has varied from 14,500 in 1971 to 90,321 in 1976, which marked the high point. Since 1977, the Agency has conducted between 50,000 and 60,000 inspections annually, while the various State Programs have conducted an additional 90,000 to 120,000 inspections. Given that OSHA and the State Programs, in theory, regulate the health and safety of nearly 4.5 million workplaces, the overall probability of inspection is quite low. In addition, the penalties levied for violations of OSHA standards are generally very low, especially compared to the costs of many controls. OSHA has tried to concentrate its inspection resources in the most hazardous industries, but even in those industries, the probability of inspection in any one year is still low. Moreover, the low average OSHA penalties, as well as variations in inspection probabilities and penalties among industries and geographic areas may hamper efforts to discern OSHA's effects on injury rates.

Second, many OSHA inspections do not find any violations or any "serious" violations. For example, the percentage of OSHA inspections finding serious, repeat, or willful violations has ranged from about 10 percent in Fiscal Year 1976 to about 35 percent in Fiscal Year 1980. Research that groups inspections without violations with inspections that found violations may mask OSHA's effect on employers who violate OSHA standards (Schneider, 1983).

Third, looking only at aggregate data for all injury types may mask OSHA's positive effect on certain types of injuries. For example, not all types of accidental injuries are equally preventable by inspections and citations for violations of mandatory safety standards. There are differences of opinion concerning the proportion of injuries that are preventable by enforcement of existing safety standards, as well as the potential effectiveness of rewritten, more stringent standards. Most would probably agree, however, that not all injury types are equally prevented by current standards, although these injuries may in theory be preventable. In addition, some types of injuries (for example, musculoskeletal injuries), are not currently addressed by OSHA standards. Data that aggregates all injury types together may mask a favorable OSHA effect on some types of injuries.

Fourth, the gradual increase in the proportion of OSHA's inspection devoted to health may also change the relative effect of OSHA on injury rates. Fifth, the effectiveness of Federal OSHA and the various State Programs may differ. Analysis of a data set that combines OSHA activity with State Program activity may not be able to show the places where there is a favorable effect.

Sixth, the effectiveness studies that have been completed have used data that derives from employer-maintained records. If there are biases in those data, or if employers keep better records after an inspection than they did before inspections, the effects of OSHA may be difficult to evaluate.

Description of Studies. To date, research results on the question of OSHA's effect on injury rates are mixed. Some studies have not been able to find any statistically significant OSHA effects, while others have found statistically significant, although small, OSHA effects.

Aldona DiPietro used a data set that provided information on individual establishments. Using data for 1972 and 1973, a comparison was made between establishments that had been inspected and those that had not. In general, the variable for the presence or absence of an inspection was found to be not statistically significant. But even more striking was the finding that in those cases in which a statistically significant result was found, 45 coefficients were positive and only 2 negative. This would imply that OSHA inspections were increasing, rather than decreasing, the injury rate. DiPietro looked at several possible explanations of this result and concluded that the most likely explanation was that OSHA inspections were not being conducted randomly. Rather, compliance officers were systematically inspecting plants with higher injury rates. This hypothesis was tested and the results indicated, with statistical significance, that the total incidence rate for the previous year and the change in the incidence rate from year to year were good predictors of whether or not a firm would be inspected (DiPietro, 1976).

Thus, OSHA may have been having a favorable effect on injury rates, but the effect could have been masked by the selection of establishments to be inspected. In other words, the rates in hazardous establishments may have been reduced from what they otherwise would have been, but may still be higher than those in establishments that were not inspected at all.

John Mendeloff (1979) found, using data for the entire U.S., no changes in the reported injury rates for 1972-75 that were significantly different from what could have been expected based on a model developed using data from 1948-1970. Using California workers' compensation data for 1948—75, he developed a second model to predict post-1970 injury rates. He then compared the predicted rates with those actually reported. For 1974 and 1975 there were slightly fewer injuries reported than would have been predicted, but the differences were not statistically significant (Mendeloff, 1979, pp. 102-8).

However, while not finding a statistically significant effect in aggregated data for U.S. or California, Mendeloff was able to disaggregate the California data by injury type. He found that the numbers of "caught in and between" injuries actually reported were substantially fewer than the number predicted by his model. This overprediction becomes statistically significant for two versions of his model in 1973 and for all four versions in 1974 and 1975. In 1975, the overprediction ranged from 21 percent to 36 percent.

Although he did not actually attempt to predict injury rates in any other states, workers' compensation data for four of five other states reveal consistent declines in the percentage of work injuries due to "caught in and between" accidents. Similarly, the rates for "falls and slips" were consistently overpredicted by his model, although the coefficients do not become statistically significant until 1974 and 1975. In 1975 the predicted rate exceeded the actual rate by 34 percent. Within the "falls and slips" category, "falls from elevation" declined relative to all "falls," again consistent with a favorable OSHA-effect. In addition, rates for "explosions" declined sharply after 1972, and for "electrocutions" after 1971. On the other hand, he found no OSHA-effect for "struck by" injuries, while the number of "strains and overexertions" have gone up.

For fatalities, he found that for "explosions," "electrocutions," and "rollovers" of earth-moving equipment, the actual post-1970 experience has been better than that predicted by extrapolation. The difference between the pre-OSHA trends and post-OSHA experience for California is a reduction of 35-40 deaths per year (Mendeloff, 1979, pp. 108-15).

Robert Smith (1976) examined the effect of the OSHA Target Industry program which during the early 1970's singled out a number of high hazard industries for priority inspection coverage. He developed a model to predict injury rates for all kinds of injuries for these targeted industries in manufacturing. Injury rates for the 1970-72 period appeared to decline by nearly 3 percent more than they would have otherwise, but for the 1970-73 period the decline was less than 1 percent. Neither result, however, was statistically significant. His sample lacked information about individual establishments which is necessary to allow a comparison of inspected versus uninspected plants (Smith, 1976).

Robert Smith (1979), in a second study, compared the injury rates of plants inspected "early" in a given year with the rates for plants inspected "late" in the year. By doing so, he focused attention on the places where an OSHA effect is more likely to be seen, that is, plants that have actually been inspected. In addition, this method allows for controlling the influence of formal or informal policies that target inspections towards the most hazardous plants. All of the plants in Smith's analysis had been selected for inspection and were actually inspected. He hypothesized that the injury rate for the year would be different depending on the time during the year that the plant was inspected. For plants inspected late in the year, November or December, the reported injury rates will almost entirely reflect the experience of the plant prior to the inspection. Any reduction due to the to the effects of OSHA will be felt the following year. For plants inspected early in the year, OSHA-induced declines in injury rates will be manifested during the course of the year.

Smith used data aggregated for all kinds of injuries from 1973 and 1974. He found a statistically significant injury rate decrease for the 1973 inspections and an insignificant decline for the 1974 inspections. He speculates that the reduced level of OSHA's effectiveness may have been due to the policy of targeting the most hazardous workplaces first, or the inexperience of a rapidly expanding force of compliance officers. His estimates imply an inspection-related decline in injury rates of about 16 percent for 1973 and about 5 percent for those in 1974. He estimated a lag of about 3 1/2 months in effective hazard abatement following the inspection (Smith, 1979).

W. Kip Viscusi (1979) used aggregated national data to test the impact of OSHA inspections and penalty amounts on injury rates. His variables for inspections were not statistically significant. His results did show statistically significant effects for a series of yearly dummy variables, indicating a consistently downward trend over time. Viscusi suggests that this could be a statistical artifact due to changes in his sample or changes in employers' reporting of injuries (Viscusi, pp. 133-5). But it could indicate a secular decline in injury rates which is either a continuation of a long term decline or a favorable effect due to OSHA. Thus OSHA's effect may be to create a general decline in rates over time, instead of an effect that correlates with year to year changes in the level of inspection activity.

William Cooke and Frederick Gautschi examined a sample of manufacturing firms in Maine (a Federal OSHA state) over the 1970-76 period. They divided their sample into groups: firms with less than 200 employees, those with 200-300 employees, and those with 300 or more employees. For the smaller plants, they did not find a statistically significant OSHA effect and ascribed this to measurement problems. For the plants with 200 or more employees, their results were significant, and imply that each OSHA citation reduced the average number of lost workdays per worker by .021 days. Given that the average number of citations per establishment inspected is equal to 13.6, each inspection yields a reduction of .29 lost workdays per worker. For plants with 300 or more employees, the average of 15.5 citations per plant times an estimated reduction per citation of .033 days per worker yields an estimated impact per OSHA inspection of .51 days per worker. The estimated reductions of .29 and .51 days per worker can be compared to the average rates (for all plants, both cited and not cited) of 1.22 and 1.38 average days lost per worker for the 200 or more and 300 or more employee subsamples. In addition, their regression equations provide some evidence that jointly administered, union-management safety committees are also effective in reducing injury rates (Cooke and Gautschi, 1981).

David McCaffrey (1983) used data from the BLS Annual Survey to update methodology of Robert Smith (1979). As described above this involves comparing the injury rates of plants inspected early in the year with those inspected late in the year. He used a data file for manufacturing and construction firms, and compared the injury experience of firms inspected in March and April with that of firms inspected in November and December. McCaffrey's analysis did not distinguish between firms inspected by Federal OSHA and those inspected by state-plan programs. He also included in his model, variables for changes in the firm's employment, its employment size, its industry, and its injury rate for the previous year. He created two different models to first examine whether OSHA inspections had an effect within the year of the inspection (i.e., whether inspections in 1976 had a measurable effect in 1976) and to second to examine the possibility if a delayed OSHA effect (i.e. whether inspections in 1976 had a measurable effect in 1977).

His analysis found that the effects within the same year for inspections in 1976 and 1978 were statistically insignificant. The one-year lagged effects of 1976 inspections on 1977 injury rates were also insignificant. There was a significant effect for the period 1977-78 for firms with 1-49 employees and those with 250-499 employees. But further analysis indicated that a few firms in the sample with anomalously high injury rates were creating biased results. Re-analysis after excluding those firms resulted in the finding that 1977 inspections had no significant effect on 1978 injury rates (McCaffrey, 1983). (For a critique of this study, see Schneider, unpublished, 1983.)

Ann Bartel and Lacy Thomas (1984) have also recently examined the effects of OSHA inspections on employer compliance and injury rates. They used data on OSHA safety inspections for the 22 jurisdictions continuously covered by Federal OSHA for 1972 to 1978. To these data, they added information from the BLS Annual Survey for the same time period and also restricted to the 22 jurisdictions under continuous Federal coverage. Finally they used information from a variety of official sources on the number and distribution of employment, unionization, age distribution, average earnings, overtime hours, new hire rates, etc. They created a three-equation model to explain OSHA enforcement activity, the extent of employer compliance with OSHA standards, and injury rates.

Their results indicate that fines do more towards compliance with OSHA standards in response to OSHA enforcement activity. A 10 percent increase in the amount of penalty per violation of OSHA standards would lead to a statistically significant increase in the compliance rate of nearly 5 percent. In addition, their results indicate that improved compliance with OSHA standards, all other things being equal, will lead to reduced injury rates. This effect is statistically significant, but its magnitude appears to be small. Their results imply current OSHA inspection activity appears to have created at least a 4 percent reduction in lost workday rates in the jurisdictions covered by Federal OSHA. But their results also imply that even if all firms were to move into compliance with current OSHA standards, injury rates would only fall 8.5 percent.

OSHA itself has analyzed the effect of one OSHA standard on the reported frequency of injuries. Between 1970 and 1978, about 47 injury-producing accidents occurred each year with one type of wheel rim used on trucks and buses. In 1980, OSHA issued a new regulation concerning the servicing of these wheels, and since then the Agency estimates that the frequency of injuries has fallen by 76 percent, to about 11 per year. A workplace standard issued by the State of California concerning another type of wheel has also led to an injury reduction of about 80 percent (OSHA, September, 1982). Although these declines are encouraging, they represent only a tiny change in the total number of work-related deaths from all causes. Moreover, this appears to be the only case for which OSHA has analyzed the actual effects of any particular safety standard on injury rates.

The Mendeloff (1979) and Smith (1979) studies have been used to estimate the possible benefits in the United States of OSHA safety regulation. Green and Waitzman (1981) have calculated that the 5 percent reduction in fatalities and a 2-3 percent reduction in lost-workday cases found by Mendeloff translates into a nationwide reduction of 350 deaths and prevention of 40,000 to 60,000 injuries per year. They also estimated that the Smith findings of 5 to 16 percent reductions in injury rates in inspected workplaces imply a reduction of 144,000 to 450,000 injuries in a year with 180,000 inspections.

Assigning a dollar value to these reductions is very difficult (see Chapter 14 of Preventing Illness and Injury in the Workplace). Using one estimate of the minimum social losses due to disabling injuries, Green and Waitzman (1981) estimate that the benefits of OSHA safety regulation are, using Mendeloff's results, at least $408 to $610 million annually. Smith's results for lost-workday cases, they argue, imply monetary benefits of up to $4.59 billion. The reduction of 350 deaths per year might be valued at over $5 billion if one "willingness to pay" estimate of the value of life is used

(Green & Waitzman, 1981).

Summary of OSHA's Impact. Two basic approaches have been used in the studies of OSHA's effects on injury rates. The first is to develop a statistical model to "explain" injury rates and changes in those rates. Such an explanatory model can include a variable that measures the activity of OSHA (usually the number of inspections per year). The analysis can examine whether changes in injury rates correlate with OSHA activity. Another use of this approach is to extrapolate results for the period before the creation of OSHA to predict injury rates. If the actual rates are below those predicted, OSHA may have been the cause.

The second major approach is to compare the injury rate experience of plants that have been inspected with those that have not. This approach encounters difficulties if OSHA tends to inspect plants with the highest injury rates. A variation is to compare the injury records of plants inspected "early" in the year with those inspected "late" in the year. Although this approach has the advantage of being able to estimate effects on inspected plants, it will not be able to detect any deterrent effect of OSHA in plants that have not been inspected.

DiPietro (1976) found that inspected firms had higher injury rates, a result that DiPietro attributed to a tendency for OSHA to inspect more hazardous plants. Smith (1976) used a model to predict injury rates in several high-hazard industries targeted by OSHA. He found declines over time, but these were not statistically significant. In a later study, Smith (1979) compared early and late inspections, finding a significant decline in 1973 and an insignificant decline in 1974. McCaffrey (1983) used the same methodology and found no significant OSHA effects in 1976, 1977, or 1978. Cooke and

Gautschi (1981) compared early and late inspections in Maine for 1970-76 and found a statistically significant reduction in the number of lost workdays per worker.

Mendeloff (1979) was able to disaggregate injury data for California by type of injury. Using a model to predict injury rates in the absence of OSHA, he found significant decreases in several types of injuries he judged more likely to be preventable by OSHA activity. This parallels research by the state of California that shows large declines in amputations, explosions, and crushing injuries (see Whiting, 1980). Mendeloff found no OSHA effect, however, for California or the Nation using data that aggregated all types of injuries. OSHA itself found that one regulation, targeted to a particular hazard, had an dramatic effect on the number of reported fatalities related to that particular hazard.

Two studies have used variables concerning the level of OSHA inspection activity. Viscusi (1979), using data that did not distinguish between Federal and State OSHA programs, found no significant effect related to the level of Federal activity. His results did reveal, however, a significant decline in injury rates over time, which may have been a statistical artifact or the result of a favorable OSHA effect. Bartel and Thomas (1984) limited their study to States covered by Federal OSHA, and found that OSHA activity had a significant effect on employer compliance with OSHA standards, but that this compliance led to only a modest reduction in injury rates.

Taken together, these results tend to support the conclusion that most of the injury rate changes since 1972 have been due to the effects of the business cycle and are not related to OSHA activities.

Effects of Mine Safety Regulation. The research concerning OSHA can be compared with research about Federal regulation of mine safety. The number of fatalities in mining has fallen during the last half-century. In 1926-30, a total of 11,175 miners were killed on the job, while during 1971-75, the figure was 715 (OTA, 1979). Congressional activity concerning coal mining has included legislation in 1941, 1952, 1969, and 1977.

Two studies have evaluated this legislation using aggregated data over time. Lewis-Beck and Alford (1980) examined fatality rates from 1932 to 1976 and concluded that Federal legislation passed in 1941 and in 1969 significantly diminished the risk of fatal injuries in mining, but that the 1952 legislation had no significant impact on fatality rates. Weeks and Fox (1983) concluded that there had been no change in underground fatality rates from 1950 to 1969, but a significant decline from 1970 to 1980. This decline in mining fatality rates may have recently reversed. Weeks and Fox (1983) found that in 1981 the fatality rate was significantly higher than would be expected from the rates from 1970 to 1980.

Three other studies have used more detailed information to control for nongovernmental factors that influence injury rates in mining. Boden (1977) found that government inspections reduced injuries and fatalities for the period 1973-75. Connerton (1978), using data from 1965 to 1975, found that the 1969 Coal Act had reduced fatality rates, but that nonfatal injury rates had stayed the same or increased slightly. Neumann and Nelson (1982) concluded that the 1969 Act had significantly reduced fatality rates (they estimated that in 1976 it had been lowered by 9 percent), but that nonfatal accident rates had risen. It is not completely clear why fatality rates have fallen while nonfatal injury rates have increased since the 1969 Act. Part of the reason may be because of improved reporting of nonfatal injuries (OTA, 1979).

Several reasons have been suggested to explain why mine safety regulation appears to have been more effective than OSHA's safety regulation in non-mining industries. First, the funding of the relevant government agencies has been greater for mine safety, about $150 per worker, as opposed to $3 per worker in general industry. Second, inspection coverage is much greater. Every coal mine is inspected every year--at least twice a year for surface operations and at least four times a year for underground operations. Third, the hazards of mining are more similar from establishment to establishment than for the wide variety of industries covered by OSHA. Thus, standards and inspections can be more narrowly focused. Finally, mine safety regulations require mandatory safety training of all miners, which includes both training for new employees and refresher training for current employees (Bolle, 1981)

Potential of Safety Regulation. Some critics believe that safety regulation itself represents the wrong approach to the problem of workplace injuries, and suggest injury taxes, workers' compensation, and tort liability as preferred alternatives (see discussion in Chapter 15 of Preventing Illness and Injury in the Workplace). Moreover, some have criticized OSHA's safety standards because they mostly concern equipment and not worker activities. OSHA's safety inspections can only detect relatively permanent features of the workplace and not the transient hazards that lead to many injuries. Thus, these critics claim, it is not surprising that the studies on OSHA's effectiveness have found only limited impact or no significant impact at all.

For example, Mendeloff (1984) found that only 13 to 19 percent of the 645 deaths reported in 1976 in California were related to violations of safety standards. He then asked a panel of safety engineers to review the written reports of these cases to determine if the violations in these cases would have been detected by an OSHA inspection on the day before the accident. Based on the panel's evaluation, Mendeloff concluded that only 55 percent of the serious violations would have been detected.

The California Department of Industrial Relations has analyzed occupational injuries and reports that between 30 and 50 percent of the injuries examined in several different industries could have been prevented by compliance with standards. Nearly all of the remaining injuries, they concluded, could be prevented by improved training and education (California DIR, #1-6). Bacow (1980) concludes that most injuries cannot be prevented by OSHA activity. To reach this he relies on studies of "unsafe acts" and "unsafe conditions" (summarized in Chapter 4 of Preventing Illness and Injury in the Workplace) and two studies in Wisconsin and New York that found violations of standards to be related to, at most, 30 percent of nonserious accidents and 57 percent of fatalities. A Federal Interagency Task Force on OSHA concluded that only about 25 percent of workplace fatalities could be prevented by present OSHA standards (Interagency Task Force, 1978).

However, often these studies do not consider how changed standards could prevent injuries. Moreover, most of these studies either explicitly or implicitly rely on the belief that most accidents are due to "unsafe acts" by workers. But, as pointed out in Chapter 4, oftentimes changes in equipment and workplace design can prevent these "unsafe acts" from occurring or reduce the potential for injury from "human errors." Similarly, new standards concerning design and installation of equipment might increase the proportion of injuries that are deemed "preventable." In addition, several of these studies automatically exclude motor vehicle fatalities as "not preventable." Current OSHA standards do not generally address motor vehicle safety, but there are technologies available to reduce the incidence of deaths in vehicle crashes (Warner, 1982). These could be mandated by the Federal Government, probably through regulations issued by the National Highway Traffic Safety Administration.

Critics of safety standards frequently point to the importance of worker training for preventing injuries. Industrial leaders in occupational safety also emphasize worker training programs. Although perhaps more difficult than regulating machinery design, OSHA could encourage or even require safety training programs. Thus new standards that improve the design of equipment, address hazards not currently regulated, or that improve training programs may have a beneficial effect on injuries.

Accuracy and Adequacy of Employer-Maintained Records

Several of the major sources of information on occupational hazards are based on records maintained by employers and reports filed by employers. As described above, prior to 1970 many criticized existing employer records of occupational injuries because these records understated the occupational safety and health problem. Although the OSH Act provided for mandatory recordkeeping and for criminal penalties for falsifying such records, the criticism persists.

In 1980 hearings were held on the proposed "Occupational Safety and Health Improvements Act of 1980." (This bill was popularly known, after the name of its first author, as the "Schweiker Bill." It should be noted however, that the bill was actually co-authored by a group that included Senators Schweiker, Williams, Church, Cranston, Hatch, & Nelson), During those hearings a number of union witnesses presented testimony concerning the inadequacies of employer-maintained records. They presented evidence of cases in which employers had paid employees for not working or placed them on light-duty work, as ways of avoiding the need to report a work-related injury. Additionally, the witnesses reported examples of situations in which employers exerted pressure on employees not to report injuries in order to reduce workers' compensation liability. The examples included the direct pressure of threatened firing as well as the indirect pressure of so-called "safety contests" in which monetary and non-monetary prizes are awarded for accident-free work.

Because the thrust of the bill was to exempt certain "low hazard" establishments from OSHA inspections (i.e. those without deaths or a lost workday case rate less than 2 per 100 workers in the preceding year), the unions and OSHA also testified to problems that arise when using establishment specific data for inspection targeting. These included the situations, for example, in many large plants with both high and low hazard areas. In such plants, the average injury rate for the establishment as a whole may be low, even though some areas are quite hazardous. The low average injury rate may, in effect, mask the more hazardous areas. Moreover, low accident rates in one year may not necessarily imply that the plant is safe. According to an AFL-CIO analysis of OSHA fatality investigation data, 41 percent of workers killed on the job in 1978 worked for establishments that would have been exempted by the Schweiker Bill. These fatalities included, most notably, the 47 construction workers killed when scaffolding collapsed during the building of an electric utility cooling tower at Willow Island, West Virginia (Hearings, Senate Comm. on Labor and Human Resources).

The fears that employers would be encouraged by the possibility of an exemption from OSHA inspections to underrecord injuries have been magnified by recent OSHA actions. Effective October 1, 1981, OSHA administratively implemented the major inspection exemption provision of the Schweiker Bill. OSHA is not using the "Schweiker Bill" criterion of a lost workday case rate greater than 2 cases per 100 employees to exempt employers. Instead, OSHA is using as its criterion a substantially higher injury rate—a lost workday rate greater than the national average lost workday rate for manufacturing. Establishments with rates below that criterion will not receive programmed safety inspections. (Specifically, the criterion was first established at 5.7 cases per 100 employees. It has been lowered four times since then: in November 1981, it was lowered to 5.4 cases per 100 employees; in November 1982 to 5.2; in November 1983 to 4.9; and to 4.2 in November 1984.)

Employers currently lack strong incentives, besides a desire to obey the law and the small threat of an OSHA citation for not maintaining records, to to collect information on injuries and illnesses. Many kinds of data are needed to manage a firm (e.g. inventory levels, receipts and expenditures) or to comply with tax laws. For these types of data, firms have direct incentives to collect the information and to do so accurately. Injury and illness reports do not directly affect the profitability of the firm nor, generally, are they used to manage its operations. Moreover, to the extent that firms wish to minimize their workers' compensation costs, they are unlikely to overreport injuries to their insurance carrier. For OSHA records, they may not devote much time or resources to maintaining the records or actively ensuring their accuracy.

In addition, employees may also have incentives to underreport. Generally workers' compensation pays only 2/3 of the employee's pre-injury wages, up to a legal maximum dollar amount. The worker receives this indemnity compensation only after a waiting period of between 1 and 8 lost workdays. In situations where employees can use company-provided sick time at full pay, vacation time at full pay, or can come in to work with other employees or supervisors "covering" for them, employees do not have any financial incentive to report the injury. Moreover, for many cases of cumulative trauma and nearly all illnesses, the employee's disability claim is likely to be contested by the employer.

Finally, employees may be hesitant to report injuries for fear that they will lose their jobs either for reporting the injury or by being judged "no longer capable of performing the job" by their employer. (There have been allegations that some firms compile lists of workers who have filed work injury lawsuits, which are made available to employers for use in screening employment applications (see, e.g., Henigson). Although such lists may not be commonly used, the employee fears are still real.

Previous Research

In light of the allegations and the relative incentives, surprisingly little research has been conducted on the question of the accuracy of injury records. In theory, a study could be conducted which would compare the employer records with worker responses to a survey and hospital and doctors' records to discover if employer records systematically understate the number of injuries. Because of the nature of occupational illness, such a study would probably have to be limited to injury records.

One NIOSH-funded study (Discher, et al) did reveal some information on the injury records question, but only as a sidelight to its main focus. The study was designed to explore the feasibility of surveying the prevalence of occupational disease using industrial hygiene surveys, employee interviews, and medical examinations. The researchers selected a sample of establishments in several industries in Washington and Oregon. They stratified their sample into four groups: lead-using industries, chlorinated hydrocarbon-solvent using industries, agriculture, and other nonagricultural industries. Teams of researchers were then sent to the selected establishments where they conducted interviews, examined plant operations, took medical/occupational histories of workers, and conducted medical examinations, during which probable occupational injuries and illnesses were diagnosed and recorded.

A comparison with the employer-maintained logs of injuries and illnesses revealed that 89 percent of the probable occupational illnesses were not recorded on the employers' logs. This result was generally expected because of the chronic nature of many occupational diseases and general problems in the recognition of the occupational causes of many illnesses. They also found, however, that 42 percent of the occupational injuries reported by employees to the researchers were not recorded in the employer records.

Care must be exercised in generalizing this result. It is based on a small sample and the industries visited were not randomly chosen, but were selected to focus on certain occupational health hazards. This by itself, however, would not be expected to bias the findings on the recording of accidental injury data. More seriously, the study was conducted between July 1972 and August 1974, relatively early in the life of OSHA. Employers may not have been maintaining the required records because they were not yet aware of the legal requirement to do so. Indeed, the researchers did not find any OSHA logs at all in 22 of the establishments visited, even though 10 of these had filed workers' compensation claims. Finally, there may also have been inaccuracies in employee recall, especially concerning when the injury occurred, although this would not necessarily bias upward the number of recalled injuries (Discher, et al).

Several other published studies have also examined the question of the accuracy and usefulness of employer-maintained records. The Insurance Company of North America (INA) examined a sample of 4,000 workers' compensation claims closed between July 1, 1971, and December 31, 1973 (Mazor, 1976). They coded six major injury-illness characteristics and compared the information from the Employers' First Report of Injury with other information that the insurance company received concerning the case, including medical reports and field reports. They found that the two sources of information were in agreement in about 90 percent of the cases.

The results of this study are limited because INA did not conduct any special investigations for the incidents coded. They relied entirely on the information generated by standard insurance investigation procedures. Those procedures are designed to ensure the validity of reported claims and to guard against overpayment of indemnity compensation or medical charges. In particular, this study did not address the question of whether all accidental injuries were in fact being reported to the insurance company.

In another NIOSH-funded study (Safety Sciences, 1978), investigations were made into the accuracy of employer records and the usefulness of currently collected accident information. The researchers visited 622 establishments in 25 industries (2-digit SIC's) in 15 states and the District of Columbia. In the course of each visit they attempted to interview two injured employees for a description of their accidents. That information was then compared to that in the employer's records.

They found that most employers use workers' compensation reports to substitute for the OSHA-required supplementary record of injuries and illnesses. Most employers did use the OSHA Log, however. The researchers concluded that most employers keep accident records primarily for workers' compensation purposes and not to aid in the identification of accident circumstances and causal factors. Indeed, the most commonly used coding system, the ANSI Z16.2 standard, is structured around descriptions of the injury rather than the circumstances of the accident. In other words, the system records the results of the accident rather than a description of the interrelated events, objects and conditions that led to the injury. These interrelations are particularly important in understanding injury causation and for designing preventive measures.

Safety Sciences also discovered that although nearly all employers were using workers' compensation First Reports to substitute for the OSHA Supplementary Record, 37 percent of the establishments were using substitute forms that did not contain all of the items required by the OSHA 101. In comparing employer information with that provided by employees, they found good agreement (90 to 95 percent of the cases examined) for employee characteristics such as social security number, age, and gender. Agreement for part of body affected was 90 percent. For nature of injury, the overall agreement was less--75 percent, but it was unambiguously clear in only 57 percent of the cases. In the other 18 percent, the researchers made inferences from the employers' records--inferences that were later verified by the employees' accounts. For accident type, the agreement was 73 percent.

But for source of injury, accident type, and activity, they discovered quality problems. Concerning the source of injury Safety Sciences found overall agreement of 76 percent, but in a large number of cases inference needed to be made from the employers' records. The information was readily and unambiguously available only 44 percent of the time. Similarly, although they were able to infer the accident type from employer records and achieve agreement with information from the employee interview 73 percent of the time, the information was readily available only 30 percent of the time. For employee activity, Safety Sciences was able to achieve agreement on generally classifying the activity in 73 percent of the cases, but in only 9 percent of the cases could they ascertain from the employers' records all four activity components (general work task, specific work task, body position and movement, and objects worked with and on) without loss of significant details (Safety Sciences, 1978).

More particularly, Safety Sciences made no efforts to find accidents that had occurred that employers had failed to record. Instead, they examined cases appearing in the employers' files and interviewed injured employees identified by those records to determine the accuracy and usefulness of employer-maintained injury records.

An OSHA-funded analysis (Arthur D. Little, 1981) of information collected during an experimental project in three area OSHA offices also shed some light on the quality of employer-maintained records. Information was collected concerning the usability of employer First Reports of Injury (used for workers' compensation) for inspection targeting. Compliance officers recorded the number of lost workday cases (from the OSHA Log) and the number of First Reports. Eighty-one percent of the establishments had a greater number of First Reports than lost workday cases, while two percent had fewer. Seven percent had an equal number of lost workday cases and first reports, while eleven percent had no cases of either type (Arthur D. Little, p. 6).

The excess in workers' compensation First Reports may be due to cases that involved medical treatment, but no lost work time, or first aid cases that included a medical payment. Neither of these categories would be included in the count of lost workdays. (Unfortunately this study did not include a count of the number of OSHA recordable, non-lost workday cases.) But it is also possible that employers were not recording cases on the Log or are failing to accurately designate cases as "lost workday" cases. The A. D. Little analysis does not provide enough information to choose between those competing explanations.

As mentioned above, Karlson and Baker (1978) found that 76 percent of the occupational deaths in Wisconsin in 1976 could be identified as workplace-related from death certificates alone and only 57 percent from workers' compensation records. Even fewer, only 35 percent of the deaths, had been reported to OSHA. Similarly, in a study by Baker, et al (1983), of 148 fatalities in Maryland, they found that each of three sources—workers' compensation claims, reports to Maryland OSHA, and death certificate listings—did not reveal more than two-thirds of all the cases eventually identified as work-related (Baker, et al., 1983, p. 692).

Finally, Lawrence Fine and his colleagues have examined the OSHA logs, workers' compensation records, and information concerning medical absences and medical cases for two plants. From the plants' medical records, they identified a large number of cases of both acute trauma and cumulative trauma that had not been recorded in the OSHA logs for these plants (Fine, 1984).

Comparison of Annual Survey and Supplementary Data System

It is possible that there might be a systematic relationship between the length of the waiting period for workers' compensation and the number of recorded occupational injuries. So, for example, employers might tend to record only disability cases with a number of lost workdays greater than the state's waiting period even though the OSHA recordkeeping regulations clearly provide that all lost workday injuries are to be recorded as such. In order to examine that suggestion, and to test the consistency of two sources of data, OTA extracted state by state information from both the BLS Annual Survey and the Supplementary Data System.

Both of these data sources are based on information deriving ultimately from employers. Thus the question of alleged under-recording of injuries cannot be conclusively answered by this examination. Under-reporting may occur in both systems and to the same degree. However, comparison of the two systems may reveal discrepancies between them. Both systems have some degree of editing or verification by the collecting agencies. BLS checks the Annual Survey reports for internal consistency, while the personnel at the cooperating state workers' compensation agencies also perform a limited screening of cases before coding them for submission to the SDS.

The universes covered are slightly different. The BLS survey covers private sector employers, excluding the self-employed, domestics in the home, and farms with fewer than 11 employees. The coverage of state workers' compensation laws varies among the states, but generally none of the groups excluded from the BLS Annual Survey are subject to workers' compensation coverage. Moreover, a number of states also exclude from mandatory coverage small employers with fewer than a certain number of employees. For these states, the number of cases reported to the SDS will tend to be slightly smaller than could be expected based on the Annual Survey. Finally, most states participating in the SDS also report cases for state and local government employees. In order to compare these two data sources, these public sector cases have been excluded from the figures reported on Tables 20 and 22.

Table 20 presents information from both data sources for the states that report to SDS only cases that involve disability days. As is shown on this table, minimum number of disability days needed before compensation is paid (the waiting period) and the case submitted to the SDS. The range is from a minimum of 1 lost workday to a minimum of 8 lost workdays.

Columns 1-3 present the number of cases involving days away from work obtained from the BLS survey for 1978, 1979, and 1980. Columns 4-6 present the number of workers' compensation cases reported to the SDS from private sector employers covered by workers' compensation laws for the same three years. The last three columns present the ratio of SDS cases to the number of Annual Survey cases. A ratio equal to one indicates that the two systems are reporting the same number of cases. Ratios less than one indicate fewer SDS cases than Annual Survey cases, while ratios greater than one show a greater number of SDS cases than Annual Survey cases.

It was expected that theses ratios would be equal 1.0 for only three states—Alaska, California, and Massachusetts. They are the only states to report all cases involving 1 or more lost workdays, the same definition used by the Annual Survey for cases away from work. California's ratios equal 1.0 or nearly 1.0 for all three years, while those for Alaska are above 1.0 and those for Massachusetts, which reports only manufacturing cases, are below 1.0.

For the remaining states it was expected that the ratios would be below unity and would decline as the minimum waiting period increases. Knowledge of the distribution of the number of cases by length of disability is needed to judge whether the general decline shown in Table 20 for those ratios is above or below that expected. Although, neither the Annual Survey nor the SDS can provide us with such a distribution, a distribution of disability cases was provided to OTA by the National Council on Compensation Insurance (NCCI).

The NCCI collected cases from a group of insurance companies for 1974. Table 21 presents the distribution of those cases by length of disability period. Table 21 represents a multi-state, multi-industry compilation of data. The distribution of accidents in a particular state or industry may differ from the NCCI distribution. Applying the NCCI distribution to the Annual Survey and SDS data to develop an "expected" number of cases that involve a specific number of disability days must be done with care.

Both Indiana and Kentucky report to SDS only cases with more than 1 lost workday. Based on the NCCI distribution, cases with 2 or more disability days comprise 91.3 percent of all disability cases. Thus we would expect that the ratio of SDS to Annual Survey cases would equal about .92. Table 20 shows that Indiana is consistently below that expected ratio (.70-.73) and that Kentucky is consistently above that ratio (1.01-1.41). (The large drop for kentucky, from 1.41 to 1.01, between 1979 and 1980, appears to be due to the inclusion, prior to 1980, of cases that did not involve more than I lost workday (Schaffer, letter).)

Iowa changed its definition from 2 or more lost workdays for 1978-79, to 3 or more lost workdays for 1980. Unexpectedly, the number of compensation cases rose by about 4,500 cases, possibly reflecting other changes in the administration of workers' compensation in that state. The SDS to Annual Survey ratios of .60 and .57 for 1978 and 1979 are below the expected ratio of.92, while the 1980 ratio of .81 is very nearly equal to the expected .83. Minnesota is consistently above the expected ration while Maryland is below. Oregon and Michigan are consistently above, while Arizona, which changed its definition between 1979 and 1980, has one year below and one year above. New Mexico is consistently below the expected ratio, but Tennessee is consistently above.

Thus no clear pattern emerges. For only one state, California, do the ratios consistently equal those expected. The other states have ratios that remain relatively consistent from year to year, but are not consistently related to what might be expected based on the NCCI distribution.

A clearer pattern does emerge in the comparison for those states that submit medical treatment and disability cases to the SDS. Table 22 presents the data for these states. Columns 1-3 present the total recordable cases from the Annual Survey, which should include all cases with one or more lost workdays or medical treatment. The Annual Survey should also include cases that involved transfer to another job, termination of employment, loss of consciousness, or restriction of work or motion. These cases may not be reported to workers' compensation if they did not also involve lost work time or medical treatment. This discrepancy is probably small and would tend to make the Annual Survey appear to overstate the number of cases relative to the SDS.

Because certain states have changed their reporting definitions, comparisons can be made only for some of the years that these states have submitted cases to SDS. In Table 22, asterisks mark the ratios for which a meaningful comparison is possible. Again, these ratios should equal one if the two systems are consistent.

Of the 20 state and year combinations that can be compared directly, 18 are above the expected ratio of 1.0, one is below (.69) and one is nearly equal to unity (.96). For these 20 combinations, the SDS has, on average, 33 percent more cases than the BLS Annual Survey reports. This indicates either that the Annual Survey is underreporting the numbers of such cases or that the SDS is overreporting. The states for which this is true, however, may not be representative of the nation. Most of the states in Table 22 are small to medium-sized states which lie outside the industrialized Northeastern and Midwestern regions.

It is not clear why these differences should exist. It could be that employers report cases to workers' compensation that involve medical charges, but which employers treat as "first aid cases" that do not need to be recorded for OSHA and BLS. It could also be that because of the financial implications of workers' compensation, more care is taken to report all cases, while less care is taken with the OSHA log and Survey reports to the BLS.

Officials at BLS believe that the Annual Survey is the single best source of data on the incidence of occupational injuries and illnesses. They believe that the differences between the Annual Survey and the SDS concerning lost workday injuries occur because in some states employers overreport injuries to workers' compensation, while in other states there is underreporting. For medical treatment cases, BLS believes that the appearance of more cases in the SDS indicates that "employers report cases which involve a medical charge [for workers' compensation], but treat them as nonrecordable first aid cases for OSHA recordkeeping purposes." Furthermore, BLS believes that employers are making these determinations appropriately.

Comparison of Annual Survey and National Health Interview Survey

Information from the National Health Interview Survey (NHIS) can also be compared to that from the BLS Annual Survey. The OSHA/BLS definition of recordable cases is similar to the NHIS definitions for injuries, although they are not identical. OSHA/BLS requires that a case be recorded if it involves death, medical treatment beyond first aid, loss of consciousness, restriction of work or motion, transfer to another job, termination of employment, or lost worktime. In addition, occupational illnesses, that are diagnosed and recognized as occupational, are to be recorded.

Work injury cases reported to the NHIS are injuries classified by nature of injury codes 800-999 of the International Classification of Diseases that are medically attended or involve a restriction of activity, and that occurred at work. NHIS does not include an occupational fatalities except in cases when the NHIS interview took place between the time of the injury and the time of death. Because most occupational fatalities are immediately fatal or involve death within a couple of days, the NHIS will not include most occupational fatalities.

Some cases involving only first aid cases may appear in the NHIS that will be excluded from the OSHA/BLS definition, but injury cases that involve either medical treatment or restriction of work should appear in both. Some cases that restrict only a person's off-the-job activities, but do not result in lost worktime, may appear only in the NHIS. Most occupational illnesses (as defined by OSHA/BLS), except for some cases of toxic effects from solvents, corrosives, metals, gases, and fumes, and some disorders due to physical agents, will not appear as injuries in the NHIS.

The universes for the two surveys are different. BLS surveys private employers and excludes the self-employed, unpaid family members for family-operated businesses, farms with fewer than 11 employees, home domestics, and government employees. The NHIS covers the entire civilian, non-institutionalized population of the U.S. Work injuries, however, are reported only for those who are currently employed including those working as an employee of someone else; those self-employed in business, farming, or professional practice; and unpaid work in a family business or farm. NHIS includes as currently employed those who had worked at any time in the two-week interview period. The NHIS therefore includes nearly everyone who works, including most of those excluded from the BLS universe.

After adjusting for the different universe sizes, it is possible to compare the results of the two surveys. OTA made this adjustment by by dividing the number of people injured while at work (reported by NHIS) by the number currently employed. (This borrows a methodology first used by Pat Breslin. See OSHA, Division of Statistical Studies, 1978.) Similar rates can be constructed for the number of restricted activity days and bed disability days.

Table 23 presents these rates and the rates for the private sector from the BLS Annual Survey. The NHIS injury rates are consistently higher than the BLS rates, and except for 1973, higher than the BLS rates for injuries and illnesses combined. This result is particularly striking because with some exceptions, most of the people included in the NHIS universe, but excluded from the BLS universe, are generally perceived to be in low risk employments. The exceptions include farmers, police officers, fire fighters, municipal sanitation workers, civilian shipyard workers, and postal workers.

It is possible that people responding to the NHIS are including as "medically attended" injuries that OSHA/BLS classifies as "first aid only," but it is also possible that the OSHA/BLS definitions of "first aid" are too broad or not clear enough. Furthermore, it is possible that employers are systematically applying the first aid definition to more cases than it should be or that they simply are failing to record cases. As is the case in any survey involving recall, there is the possibility that the injured or the family member being interviewed may not correctly remember the injury, its "work-relatedness" or the date of occurrence. But on the other hand, the NHIS only includes cases occurring during the previous two week period to minimize this problem. In addition, it is not clear in which direction such errors in memory would bias the survey responses.

For days of lost worktime and restricted activity, the BLS and NHIS definitions are not exactly the same. For 1980, BLS estimated that there were 63.7 lost workdays, including 58.7 days away from work and 5.0 days of restricted work activity for each 100 workers. BLS and employer records generally do not include any days of disability or restricted activity that an employee may suffer on weekends or other non-workdays. The NHIS includes all days of bed disability or restricted activity, whether or not the person would have worked on that day. The 1980 NHIS rate of 43.7 bed disability days per 100 currently employed may be consistent with the BLS rate of 58.7 days away from work. After all, not all injuries that would keep a person from performing his/her normal job duties, especially those involving manual labor, would necessarily confine that person to bed.

But the NHIS rate of 189.3 days of restricted activity per 100 currently employed is about three times the BLS rate for lost workdays. This difference cannot be explained by the inclusion of non-workday activities. Some of the difference may be due to the NHIS definition of restricted activity, but it is also possible that employer records do not accurately reflect the number of days of lost work and restricted work activity.

Summary of Comparisons

The differences between the number of cases reported to the BLS Annual Survey and to the SDS through workers' compensation may or may not be important. The comparison for lost workday cases, although limited by the use of a 1974 distribution of injuries by disability days seems to indicate that the SDS and Annual Survey data are consistent with each other. This increases confidence in the use of SDS data for analyzing workplace injuries.

The differences between the SDS and Annual Survey for medical treatment cases seem to imply that cases are being reported to SDS that are not then reported on the Annual Survey. This could be due to cases that are treated by doctors, but that do not result in lost worktime. Because of the medical treatment costs, employers file a workers' compensation claim, but for some reason, these are not included in the Annual Survey. This could be due to difficulty in interpreting the distinction between "medical treatment cases" and those that require only first aid. It could also be due to an overly broad definition of first aid cases.

The SDS and Annual Survey data both ultimately derive from employers' records. The Annual Survey and NHIS are independent sources. Comparison of the Annual Survey with NHIS shows that in recent years, overall injury rates based on the NHIS are about one-third higher than those from the BLS Annual Survey. This discrepancy could arise from the different methodologies of the two surveys. As such, the differences may not be worrisome. Or it could be that employers are systematically failing to record certain injuries, or are labelling these injuries as minor injuries involving only first aid treatment, even though employees consider them serious enough to report them to the NHIS.

Finally, it is possible that the discrepancy could be confined to one group of employers. In particular, as discussed above, small employers may not be reporting all injuries. If it is assumed that injury rates are linearly related to employment size, then injury rates of approximately 12 per 100 workers would be expected for establishments with fewer than 100 employees. This contrasts to the rates observed in the BLS Annual Survey of the 3.6

per 100 (20-49 employees), and 10.9 per 100 (50-99 employees). The rate of 12 per 100 might be applied to the approximately 30 million who work in establishments with fewer than 100 employees. The additional injuries amount to over 2 million. This by itself could remove most of the discrepancy in recent years. Such an adjustment would, however, induce a discrepancy for several of the years between 1973 and 1976.

Occupational Illnesses

Number of Occupationally-Related Disease Cases

Compared to the data available on occupational injuries, very little reliable information is available to quantify the extent of the occupational illness problem. The OSHA recordkeeping requirements mandate that all employers record all cases of diagnosed, occupational illness. The BLS Annual Survey includes these cases and for 1980 it provides an estimate of 130,200 recordable occupational illnesses in the U.S. private sector. As Table 24 shows, the largest single group of these are skin diseases, mostly dermatitis, for which the occupational connection is relatively clear.

For several reasons the relationships between occupational factors and illness often go unrecognized. Occupational factors can cause diseases, contribute to diseases, or aggravate diseases which were primarily caused by other factors. Some diseases can be reliably linked to the workplace. But for many, the connection currently cannot be made because cause and effect relationships have not been established or are difficult to prove because of confounding factors. In addition, often times occupationally-caused disease is not distinguishable from that caused by nonoccupational factors. The long latent period of certain diseases and the lack of physician training in the recognition of occupational disease further compound the twin problems of discovering the occupational connection and then recording or reporting that discovery. The BLS Annual Survey and most employer records currently miss occupational diseases that are chronic, not recognized as occupationally caused, or manifested only after a latent period. (For a discussion of these issues, see Hilaski.)

The most widely quoted estimates of the number of occupational illnesses and the number of deaths due to occupational illness are 390,000 illnesses and 100,000 deaths per year. The 390,000 illnesses appears to have been a projection based on "First Reports" from the California workers' compensation system. The "First Reports" used were probably not Employers' First Reports, but reports from attending physicians also required under California law. The number 390,000 appears in the legislative history of the OSH Act (See House Report 91-1291, p. 15 and Senate Report 91-1282, p. 3) and in the *President's Report on Occupational Safety and Health for 1971* (dated May, 1972, p. 111.) Unfortunately, the methodology for developing that estimate has been lost.

That *President's Report* also introduced the estimate of 100,000 occupational deaths. To quote from the report:

> Based on a limited analysis of violent/non-violent mortality in several industries (see Table 5-1) there may be as many as 100,000 deaths per year from occupationally caused diseases (p. 111).

The table referred to presented the results of three epidemiologic studies for underground metal miners, smelter workers, and uranium miners. The report does not state exactly how the 100,000 deaths was derived, but it appears that someone used the data from those three studies to develop a ratio of excess non-violent deaths to violent deaths. That ratio was approximately 7 to 1. Then by assuming that these three groups were representative of all workers and that all the non-violent deaths could be attributed to occupational factors it is a simple matter to multiply the number of occupational deaths estimated by the National Safety Council (about 14,000 in the early 1970's) by 7 to obtain an estimate of about 100,000 deaths.

The NIOSH Division of Surveillance, Hazard Evaluation and Field Studies subsequently estimated the number of deaths due to occupational disease by another method. Using the 1951 Registrar-General's Occupational Mortality Report for England and Wales, they grouped together all the occupational classifications for which the mortality rates were greater than those for the general population after adjusting for age and social class. The number of deaths above those which would be expected, based on age and social class, were then summed for these occupations and treated as occupational disease deaths. The resulting figure was divided by the total number employed to yield an occupational disease death rate. That death rate was applied to an estimate of the number of people employed in the U.S. This results in an estimate of about 75,000 deaths. If the adjustment for social class was ignored, the estimate would be about 100,000 deaths.

This second derivation also has limitations. First is the use of a British death registry from 1951. There may be a number of differences between the U.S. and Britain terms of production techniques, workplace health and safety conditions, nonworkplace environmental factors, and definitions of occupational categories. Moreover, data from 1951 may not accurately characterize the situation today. But, the net direction of these possible biases and the extent of the error are not clear (Barth and Hunt, 1980, p. 17).

Barth and Hunt report two other estimates of the annual number of fatalities caused by occupational factors. The first was apparently prepared by an unnamed panel of The National Institutes of Health. This estimate was that between 107,200 and 193,800 deaths per year are due to occupational causes. The estimate appears to have been created using vital statistics data for 1974 and then estimating the fraction of deaths from cardiovascular disease, cancer, and pulmonary disease that are caused by occupation. The assumptions were that 5-10 percent of the approximately 1 million cardiovascular deaths are due to occupation (or 50,500 to 101,000 deaths); 15 to 25 percent of 360,000 cancer deaths (or 54,000 to 90,100 deaths); and 10 percent of pulmonary fatalities. (These numbered about 27,000 after excluding deaths from pneumonia and influenza. Ten percent of these is equal to 2,700). The grand total then is 107,200 to 193,800. Barth and Hunt provide no additional details on the source or derivation of these assumed percentages attributable to occupational factors.

The second source of estimates reported by Barth and Hunt comes from John Peters, who estimated in one publication that a "conservative estimate based on known effects of occupational exposures" would be 10,000 deaths due to occupational disease. In later correspondence with Barth, Peters stated that he thought another estimate was closer to the truth, a range of 124,000 to 210,000. (Barth and Hunt, 1980, pp 17-20)

The number of occupationally-related cancer deaths has been the subject of a very heated debate. This debate gained a special intensity with a paper prepared for the OSHA Hearings on its "Carcinogen Policy" by a group of researchers at the National Cancer Institute, the National Institute for Environmental Health Sciences, and NIOSH.[1] That paper estimated that the total of occupationally related cancers from six known carcinogens constitutes 23-38 percent of the overall cancer toll. On contract to OTA, Richard Doll and Richard Peto reviewed these estimates and concluded that they were in error because of the implicit assumption that workers are currently exposed to the same levels of these 6 carcinogens as were the heaviest-exposed workers in the past. Doll and Peto estimated that occupational factors cause approximately 4 percent of U.S. cancers, with an acceptable range of from 2 to 10 percent (OTA, 1981, Doll and Peto, 1981).

The debate over the relative contributions of various factors to the incidence of cancer still continues. OTA (1981) reviewed the available estimate of the percentage of cancer associated with occupation and suggested that most estimates fit within a range of 5 to 15 percent. A 1981 Banbury House Conference (Peto and Schneiderman, 1981) on the quantification of occupational cancer produced general agreement that occupational cancer represents less that 10, and probably less then 5 percent of all cancer. However, some experts present at the meeting disagreed with that conclusion. (See, for example, Davis, Bridbord and Schneiderman, 1981; Schwartz and Epstein, 1981.)

A report to Congress on occupational diseases and the compensation of occupational diseases prepared by the Department of Labor's Office of the Assistant Secretary for Policy, Evaluation, and Research (ASPER), also contains estimates of the number of occupationally-related diseases. Using the results of a number of epidemiologic studies and information on the number of workers exposed, ASPER estimated the incidence of disease for several substances. The estimates were that about 2,200 deaths would occur per year as a result of current exposures to beryllium, cadmium, arsenic, chromium, nickel, and coal tar products. In addition, estimates were made of the prevalence of disease related to exposures to three other hazards. For cotton dust, the estimate was 84,000 disabling conditions, of which 30,000 would be totally disabling. For silica, about 59,000 cases of silicosis were estimated, as well as about 43,000 cases of lung impairment for exposures to di-isocyanates (ASPER, 1980, p. 38).

---

[1] This paper, now published as an appendix to a recent Banbury House Conference Proceedings, has been known as the "Estimates Paper," "Bridbord, et al," and even the "OSHA Paper."

These estimates have also been criticized (Hilaski and Wang, 1982). Some of their criticisms concern methodological issues too detailed to discuss here. But one criticism parallels the Doll and Peto criticism of the "Estimates Paper." This concerns the difficulties of applying prevalence or incidence rates developed from epidemiologic studies of groups of workers, to workers not studied. The crucial assumption is that the more general worker population has exposure conditions similar to the population studied. This may be the case, but owing to the lack of detailed exposure information—including data on the number of workers exposed, the level of exposure and its duration—it is difficult to conclude with certainty that the conditions are indeed similar.

This general lack of information about exposure makes it difficult to estimate the toll of occupational diseases and to evaluate the effectiveness of OSHA policies and other strategies and techniques for improving workplace health and safety. This lack of exposure information is serious and is discussed more fully below.

Understanding the limitations of previous estimates, NIOSH is currently developing new and more detailed estimates. The first product of their deliberations is a ranking of the top 10 occupational safety and health problem areas, which is included here as Table 25. Work is now proceeding on developing numerical estimates for these areas.

It must be noted, however, that although there have been intense debates on the proportion of disease caused by occupational factors, there is general agreement that when workplace hazards are revealed in defined industries or worker populations control technologies should be applied to reduce the risk of disease. Indeed, the workplace represents one environment where control can be particularly effective.

Moreover, even if the percentage if disease due to occupation is relatively small, the absolute magnitude may be large. In 1979, about 400,000 Americans died of cancer, 50,000 died from chronic pulmonary disease (this excludes deaths due to pneumonia and influenza) and 950,000 died of cardiovascular disease. If only five percent of each of these categories were due to occupational factors, the total would be 70,000 deaths per year. If it is assumed that 10 percent of chronic pulmonary disease, 5 percent of cancers, and 2 percent of cardiovascular disease are work-related, then the total would be 44,000. Similarly, if 15 percent of chronic pulmonary disease cases, 10 percent of cancers, and 5 percent of cardiovascular disease cases have occupational origins, the total would be 95,000 deaths per year. The great uncertainty in current estimates is so large that it is impossible to chart trends with any confidence.

Finally, it must be emphasized that disease is often "caused" by a variety of factors. In some cases, workplace conditions by themselves will give rise to the disease. In other cases, occupational factors, in culmination with other factors will lead to disease, even though no one of these factors would have done so individually. In still other cases, workplace conditions will aggravate diseases that had their primary cause outside of the workplace environment. Thus, workplace conditions might "contribute" to the development or aggravation of diseases for which the "primary cause" lies outside the workplace.

Prevalence of Occupationally-Related Disability

The ASPER report used a different methodology to estimate the number of persons whose total or partial disability was due to occupational factors. Data from the 1972 and 1974 Survey of Disabled and Nondisabled Adults of The Social Security Administration were used. That survey asked "Was you main condition or illness caused by your job?" The survey itself did not collect objective medical data on these individuals. Although self-reported causes present numerous problems for interpretation, in this case, it is not clear to what extent this creates a bias.

These estimates have been updated using information from the 1978 Survey of Disability and Work. These survey results imply that there were about 8 million adults aged 18 to 64 who were totally unable to work in 1978. Of these, over 1.7 million may have a work-related disability—1.3 million related to an accident or injury on the job, while 424,000 have a disability "caused by bad working conditions, such as noise, heat or smoke." Of the 12.2 million persons who were partially disabled in 1978, job-related factors may be the main cause for over 2.5 million. Of these, 1.97 million relate to an on-the-job accident of injury, while another 554,000 might be related to "bad working conditions" (Shor, pp. 18-9).

Discher Study

The results of one study show some of the limits of employer records and BLS Survey results based on employer records for estimating the incidence of occupational illnesses (Discher, et al). As noted above, these researchers selected a sample of establishments from four industries: lead-using industries, chlorinated hydrocarbon-solvent using industries, agriculture and other nonagricultural industries in Washington and Oregon. Teams were sent to 136 plants to examine plant operations and to conduct medical examinations from July 1972 to August 1974. Medical exams were given to 908 workers in these plants and 1,116 medical conditions were identified among these workers. Thirty-one percent of these were judged to be as "probable occupational disease," a judgment based on manifestations of disease consistent with the agents that had been found in the employee's workplace (based on the plant visits) and to which the employee was likely to have had "significant contact in the course of normal duties" (Discher, et al, p. 25, p. 41).

Some of the 1,116 conditions were judged to be "doubtful occupational disease," indicating that the employee's symptoms were not entirely consistent with the known effects of exposures or that it could not be established that the employee had had contact with whose agents. Others were classified as "cannot be evaluated," indicating that association between the medical condition and occupational factors has not been established. In all, 14 percent of the medical conditions were judged to be "doubtful" or "cannot evaluate." Ten percent were categorized as having a "suggestive history," indicating that the employee's history had diseases that were consistent with exposures, but that "no objective evidence of the disease" existed at the time of the examination. Finally, 45 percent of medical conditions were judged to be non-occupational (Discher, et al 1975, p. 41, p. 25).

In addition, the researchers examined employer workers' compensation claims, and their OSHA logs. These were combined with the results of the medical survey to develop an unduplicated count from all three sources of 1,456 probable occupationally incurred conditions from among the 2,040 workers eligible for the medical examination. For various reasons, only 908 of these 2,040 workers actually participated in the medical examinations. For these 2,040 workers, the researchers found a total of 1,456 conditions, probably occupationally incurred—1,005 injuries and 451 diseases.

For the 451 cases of probable occupational disease, 89 percent were discovered only through the medical examination. Two percent were found only on the employers' logs, three percent from workers' compensation claims, and six percent from more than one source. Most of the cases found on the log were acute conditions.

This study was only a pilot study which used a nonrandom sample of establishments in two states for several industries. In addition, the one-time nature of the medical examinations and industrial hygiene walk-throughs increase the chances that disease cases and exposures would be missed. Thus care must be taken in generalizing these findings. The prevalence of occupational disease, calculated from these results, 28.4 cases per 100 workers, may therefore not be applicable to a larger population.

It is clear, however, that the researchers discovered a large number of cases that were not being recognized by employers and employees as occupational. Further research using a similar methodology in a more general selection of industries and geographic areas would resolve the question of the extent of the occupational disease. At the present time, it appears likely that the burden of occupational disease is consistently underestimated by using employers' logs and the BLS Survey.

Data on Exposure

Because of the lack of an accurate accounting of the extent of occupationally caused illness, it is important that information on the extent of workers exposures be developed. Exposure information can serve several purposes: First, it can be used to quantify the extent of the problem, giving policy makers and citizens a sense of its magnitude.

Second, if collected properly, it can be used to chart progress over time. This use is particularly important in the cases of diseases with latent periods. Otherwise, successes or failures in controlling workplace health problems will only be noticed 20, 30, or 40 years in the future. Such a delayed measure of effectiveness is insufficient for a program of preventive public health. In addition, as noted above, the uncertainties found in current estimates of the magnitude of occupational illness are so large that they preclude an accurate tracking of trends.

Third, the development of accurate and comprehensive exposure data can greatly assist in the conduct of occupational epidemiology, the development of information for risk assessment and economic analyses, and the creation of more reliable estimates of the size of the occupational disease problem.

THe NIOSH National Occupational Hazard Survey has been frequently used to describe the current number of workers exposed to particular workplace hazards. Although the NOHS estimates allow for distinguishing between "full time" exposures (4 or more hours per day) and "part-time" exposure (less than 4 hours per day), no information was developed concerning the level of exposure. This has limited the usefulness of the NOHS data, although taking thousands of exposure samples and conducting laboratory analyses would dramatically increase the costs of this data collection effort.

As part of its health inspections, OSHA collects and analyzes exposure samples. One possible mechanism for developing exposure estimates that provide information on both the number of employees exposed as well as the levels of exposure would be to use the OSHA Management Information System (MIS). In a contract report prepared for OTA, John Mendeloff examined the health inspection data contained in the OSHA MIS (Mendeloff, 1983). Mendeloff's analysis addressed two principal questions:

> 1. what characteristics of establishments influence how well they control toxic exposures?
>
> 2. Is there any evidence that exposures have declined over time or that OSHA can claim credit for those reductions? (Mendeloff, 1983, v)

In addition, Mendeloff's research provides insight into the usefulness of the MIS data for creating estimates of worker exposures.

The OSHA MIS system recorded for 1972-79 the level of measurable exposures within ranges and from 1979 to the present records the precise level measured. Inspectors also estimate the number of employees who are "similarly exposed." In theory, this information might be combined with other information on the number of establishments and employees in particular industries to produce estimates of worker exposures.

But as Mendeloff notes, one drawback to the MIS data is that it is not based on a random sample. Inspections are scheduled in industries and establishments which OSHA expects to be more hazardous than average. In addition, even for plants that have been inspected, in a large number of cases during the period 1972-79, the exposure sampling data were not entered into the MIS computer. OSHA officials state that this second problem is currently being corrected with changes in the MIS.

The bias inherent in the selection of more hazardous workplaces is more difficult to correct, but it may be possible to assess its magnitude through a careful comparison of inspection data with exposure estimates from NOHS and various economic impact statements prepared for OSHA. Another possibility would be to incorporate a randomly selected sample of establishments into the OSHA inspection targeting system, with a goal of developing generalizable estimates of exposure levels (Mendeloff, 1983, pp. 66-71).

Trends in Exposure Levels and The Impact of OSHA

It is often asserted that exposures have been going down over time. However, data that would enable evaluation of this claim are scarce. Some individual firms have conducted industrial hygiene measurements for some time, but it is not clear that, even if the records from these firms had been maintained and were made available, it would be appropriate to generalize from their experience. Moreover, although some exposures may have declined, some certainly have risen. Whole categories of substances, some of which present hazards to workers, were first created only in the last half-century. Significant numbers of workers have become exposed to these substances only in the last few decades. On the other hand, a number of hazards have been around for a very long time indeed.

In addition to charting our society's progress over time in controlling exposures, it would be useful to also judge the impact of OSHA on the trend in exposure levels. Of course, this evaluation encounters similar, but not identical, problems to those found when evaluating OSHA's impact on injury rates. Basically, an appropriate evaluation must attempt, as far as possible, to control for other factors that influence exposure levels for injury rates. These include the business cycle and the pace of production, the age and experience of the workforce, the composition of the workforce by industry and occupation (see discussion above). For hazardous exposures, comparatively little research has been conducted to to identify the factors that influence exposure levels.

In his report to OTA, Mendeloff used the information recorded in the OSHA Management Information System from the OSHA-1 (a form completed for each inspection) to learn to what extent that information might explain variations in compliance among firms. Once the factors that influence the degree of compliance with OSHA's standards or the levels of exposure are identified, the techniques of multiple regression analysis can be used to analyze the effects of OSHA independent from these other factors.

Mendeloff examined in detail the MIS data for four substances—asbestos, trichlorethylene, silica and lead. For asbestos, most of his measures of exposures declined over time. Analyzed another way, the proportion of samples showing exposures above the PEL have declined dramatically. The percentage of samples showing exposure above the PEL declined from 12.0 percent in 1973-75 to 5.9 percent in 1979-81. This decline appears even though the PEL was lowered from 5 fibers per cubic meter to 2 fibers per cubic meter on July 1, 1976. If the 1979-81 data are adjurted to take account of this change, the decline is from 12.0 percent overexposures in 1973-75 to 1.9 percent—a dramatic decline.

For trichlorethylene, lead, and silica, Mendeloff's analysis is not able to show any clear changes. It is probable that there have not been any major declines in these exposures.

Mendeloff did not analyze as extensively the data for vinyl chloride exposures, but the data for exposures to this instance show substantial declines. The OSHA standard was 500 ppm until April 1974 when an emergency temporary standard of 50 ppm was established. A permanent standard of 1 ppm went into effect in 1975 although OSHA allowed the interim use of respirators for one year. Although fears were expressed that compliance with the standard would destroy the affected industries financially, firms were able to comply fairly quickly. In fact, the impetus of the standard led, in part, to the development of techniques that enhanced productivity. (For additional discussion of the issue of productivity and health and safety regulation, see Chapter 16 of Preventing Illness and Injury in the Workplace.)

The degree of compliance with the vinyl chloride standard can be examined over time with OSHA inspection data. From January 1973 through June 1974, 22 of the 622 exposure samples for VC revealed overexposures. For July 1974 through June 1975, 531 of 1,931 samples or 27.5 percent revealed overexposures to the lower, more stringent PEL's. For April 1979 to July 1981, 27 of 148 samples (18.2 percent) showed overexposures. These results are consistent with reports that the industry, which in 1974 had average exposures of 5 to 15 ppm for most workers, had achieved general compliance with the new 1 ppm limit (Mendeloff, 1983, p 62, Table 20). It has been estimated that the vinyl chloride standard would prevent about 2000 deaths over the years 1976-2000 (cited in Ashford, Hill, Mendez et al., 1980).

Using OSHA inspection data, Carol Jones (1982) has also found declines in asbestos exposures. She estimates that the decline in average exposures from the period 1972-1976 to 1977-1979 amounted to about 3 fibers per cubic centimeter. This exposure decline is equal to the decline in 1976 of the permissible exposure limit from 5 fibers per cubic centimeter to 2 fibers per cubic centimeter and thus may be linked to the OSHA standard (Jones, 1982). However, other factors, particularly the increase in the number of lawsuits concerning asbestos-related disease, may also have contributed (see Chapter 15 of Preventing Illness and Injury in the Workplace).

It has been estimated that the OSHA asbestos standard issued in 1972 would result in a reduction of between 630 and 2,563 deaths per year, resulting in social cost savings, in 1970 dollars, of between $110 and $652 million per year (Settle, 1975). These totals may underestimate the benefits of the asbestos standard (Settle, 1981).

Two of the case studies commissioned by OTA for this assessment also provide information in changes in worker exposure levels following the issuance of an OSHA standard. Ruth Ruttenberg studied changes in the cotton textile industry that occurred as a result of the OSHA cotton dust regulation, especially the implementation of new technologies and plant modernization in that industry. Ruttenberg concludes that since implementation of the standard substantial progress has been made in compliance.

For example, the Stevens Company says its plants are 87 percent in compliance with the OSHA cotton dust regulation. Industry spokespersons, including those at The American Textile Manufacturing Institute, are using a rule-of-thumb of around 75 percent compliance. Many of the newly modernized plants are already totally in compliance with the law. In July 1981, the state of North Carolina mailed questionnaires to the 992 North Carolina companies affected by the OSHA cotton dust standard. Of those replying, through the end of 1981, in every area of production at least half of the companies believed themselves in compliance with the 1984 permissible exposure limits. In over half the production areas, more than 80 percent of the companies claimed they were already in compliance, with 2 1/2 years still left before compliance was required.

Some problem areas, however, may exist for some firms and some processes. Dust control equipment manufacturers will not always guarantee compliance with the 200 ug/m^3 for ring spinning, spooling, winding, and twisting. But the progress since promulgation is very impressive.

Whereas 35 percent of active exposed textile workers in 1978 worked in areas of dust above the level of the standard, by 1982 the percentage had been cut nearly in half. Results of a recent study for OSHA by Centaur Associates found that in 1982, "about 81 percent of the active exposed worker population was estimated to be at or below the current cotton dust standard." This average represented approximately 72 percent of workers in cotton preparation and yarn processing and a full 98 percent of workers in cotton weaving and slashing. Centaur found several mills with all departments in compliance and suggested that even a 100 ug/m^3 exposure limit may be technologically feasible (Ruttenberg, 1983, pp. 50-52).

Robert Goble, Dale Hattis and colleagues examined information on lead exposure levels and worker blood lead measurements for three industries—primary smelting, secondary smelting and battery manufacture. Table 27 summarizes the information on employee exposures to airborne lead, measured in micrograms per cubic meter averaged over an eight-hour day. 1977 is the last year prior to promulgation of the lead standard in 1978 and it is used as a base line although litigation over this standard continued until 1981. Due to the delayed implementation schedule contained in the standard the requirements for engineering controls in these industries have not yet become effective.

Notwithstanding these factors, there has been a substantial reduction in worker exposures to lead in the air, without taking into account the effects of respirator use. In primary smelting, the percentage of workers exposed above 200 ug/m^3 has fallen from 61.0 percent to 44.9 percent. For secondary smelting the decline is slightly larger---from 67 percent above 200 ug/m^3 to 39.9 percent. For battery manufacture the decline has been even greater, in relative terms, from 21.0 percent above 200 ug/m^3 to 5.4 percent. In addition, the percentage exposed to levels between 100 and 200 ug/m^3 has declined from 23.0 percent to 13.2 percent. The industries analyzed still have some distance to go before achieving complete compliance with OSHA's PEL of 50 ug/m^3, but the progress to date has been impressive, especially when it is noted that, according to Mendeloff's analysis of OSHA inspection data, little change had been seen in lead exposures from 1973 to 1979.

For lead there is also a biologic measure---the amount of lead contained in the blood stream. Although it is not a perfect indicator of health hazard, reductions in blood lead levels should mean improved worker health. Table 26 presents information about employee blood lead levels. The analysis of Goble and Hattis show that there have been very substantial declines in blood lead levels. The percentages of workers with blood lead levels above 80 ug/100 g has declined from 2.0 percent to 0.1 percent in primary smelting, from 16.0 percent ot 0.6 percent in secondary smelting, and from 6.0 percent to 0 for the battery manufacturers for which data was available. In addition, there have been large declines in the percentage of workers with blood lead levels in the 60 to 80 ug/100 g range. For primary smelting the decline is from 26.0 percent to 4.6 percent, for secondary smelting it is 25.0 percent to 7.0 percent, and for battery manufacture it is 25.0 percent to 2.1 percent (Goble, Hattis, et al, 1983, pp. 3-3 to 3-14).

A complete analysis must also consider the effect of confounding variables. In this case, it is possible that some of the observed decline is due to recent changes in environmental exposures to lead that result from restrictions on the use of lead in gasoline. In addition, the relative contributions of reduced air exposures, changed work practices and respirator use to these declines is difficult to separate. But even with these limitations, it is clear that both air lead levels and blood lead levels have declined significantly and have done so in response to the issuance of a new, more stringent OSHA standard.

Conclusion on Occupational Illness and Exposure Data

Although some quantitative information is available on occupational illnesses and exposures, the amount is substantially less than what is readily available for occupational injuries. Moreover, in the words of J. Donald Millar, the current Director of NIOSH, the surveillance of occupational disease is "at least 70 years behind the field of communicable disease control" (Millar, 1984). The House Government Operations Committee (1984) recently issued a report listing its recommendations for improvements in the collection of information concerning occupational disease. Several options for improvement of data sources useful for the identification of occupational disease and the conduct of epidemiology are presented in Chapter 1 of the main report of this assessment, Preventing Illness and Injury in the Workplace.

References

N. Ashford, C. Hill, W. Mendez, et al., *Benefits of Environmental, Health, and Safety Regulation*, study prepared for the U.S. Senate Committee on Governmental Affairs, committee print, March 25, 1980.

Arthur D. Little, Inc., "Assessment of the Multi-Region Targeting Alternative Project," prepared under contract to OSHA, Office of Policy Analysis, Integration, & Evaluation, Dec. 30, 1981.

Thorne Auchter, Asst. Sec. for Occupational Safety and Health, comments on draft report, letters to OTA, Feb. 3 and Feb. 23, 1984.

Lawrence S. Bacow, *Bargaining for Job Safety and Health* (Cambridge, MA: MIT Press, 1980).

Susan Baker, Judith Samkoff, Russell Fisher, & Carol Van Buren, "Fatal Occupational Injuries," *Journal of the American Medical Association*, (248, 6), August 13, 1982, pp. 692-7.

Peter Barth with H. Allan Hunt, *Workers' Compensation and Work-Related Illnesses and Diseases*, (Cambridge, Mass: MIT Press, 1980).

Ann P. Bartel and Lacy Glenn Thomas, "OSHA Enforcement, Industrial Compliance, and Workplace Injuries" (photocopy, May 1984).

Leslie Boden, *Coal Mine Accidents and Government Enforcement of Safety Regulations*, unpublished Ph.D. dissertation, Massachusetts Institute of Technology, 1977.

Mary Jane Bolle, *OSHA Reform: An Economic Analysis of the Occupational Safety and Health Act*, Congressional Research Service, U.S. Congress, Report # 81-162E, August 6, 1981.

California Department of Industrial Relations, Division of Labor Statistics and Research, *Iron and Steel Foundries*, Research Bulletin # 1, June 1977.

California Department of Industrial Relations, Division of Labor Statistics and Research, *California Logging Industry: Analysis of Work Injuries and Illnesses*, Research Bulletin # 2, November 1978.

California Department of Industrial Relations, Division of Labor Statistics and Research, *California Sawmills and Planing Mills Industry: Analysis of Work Injuries and Illnesses*, Research Bulletin # 3, December 1978.

California Department of Industrial Relations, Division of Labor Statistics and Research, *California Fabricated Structural Metal Products Industry: Analysis of Work Injuries and Illnesses*, Research Bulletin # 4, December 1978.

California Department of Industrial Relations, Division of Labor Statistics and Research, *California Meat Products Industry: Analysis of Work Injuries and Illnesses*, Research Bulletin # 5, December 1979.

California Department of Industrial Relations, Division of Labor Statistics and Research, *California Roofing and Sheet Metal Work: Analysis of Work Injuries and Illnesses*, Research Bulletin # 6, October 1982.

Ronald F. Chamblee and Marshall C. Evans, "New Dimensions in Cause of Death Statistics," *American Journal of Public Health*, November 1982, pp.1265-70

James Chelius, "The Influence of Workers' Compensation on Safety Incentives," *Industrial and Labor Relations Review*, (35,2) January 1982, pp. 235-42.

M. Connerton, *Accident Control Through Regulation: The 1969 Coal Mine Health and Safety Act Experience*, unpublished Ph.D. dissertation, Harvard University, June 1978.

William Cooke and Frederick Gautschi, "OSHA, Plant Safety Programs, and Injury Reduction," *Industrial Relations*, (20,3), Fall 1981, pp. 245-57.

Devra Lee Davis, Kenneth Bridbord and Marvin Schneiderman, "Estimating Cancer Causes: Problems in Methodology, Production and Trends," in Richard Peto and Marvin Schneiderman, eds. *Banbury Report 9: Quantification of Occupational Cancer* (New York: Cold Spring Harbor Laboratory, 1981).

Aldona DiPietro, "An Analysis of the OSHA Inspection Program in Manufacturing Industries, 1972-73," (ASPER, U.S. Dept. of Labor: Technical Analysis Paper, August 1976).

David Discher, Goldy Kleinman, & F. James Foster, *Pilot Study for Development of an Occupational Disease Surveillance Method*, (NIOSH Publication No. 75-162, May 1975).

Richard Doll and Richard Peto, "The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in the United States Today" *Journal of the National Cancer Institute*, 66:1191-1308, 1981.

L. J. Fine, et al, "An Alternative Way of Detecting Cumulative Trauma Disorders," *Proceedings of the 1984 International Congerence on Occupational Ergonomics*, pp. 425-29, cited in testimony of Eric Frumin before the Subcommittee on Manpower and Housing, House Committee on Government Operations, U.S. Congress, *OSHA Injury and Illness Information System*, Hearing, June 20, 1984 (Washington, DC: U.S. Government Printing Office, 1984).

Robert Goble, Dale Hattis, Mary Ballen, Deborah Thurston, "Implementation of the Occupational Lead Exposure Standard," contract report prepared for the Office of Technology Assessment, U.S. Congress, November, 1983.

Jerome Gordon, Allan Akman, & Michael Brooks, *Industrial Safety Statistics: A Reexamination*, (New York: Praeger, 1971).

Michael Gorham, "Bum Rap for OSHA?" *Federal Reserve Bank of San Francisco Weekly Letter*, January 19, 1979, pp 1-3.

Mark Gottlieb and Pat Coleman, "Inspection Impact on Injury and Illness Totals," Wisconsin Dept. of Industry, Labor, and Human Relations, (photocopy, no date).

Mark Green and Norman Waitzman, *Business War on the Law: An Analysis of the Benefits of Federal Health/Safety Enforcement*, 2nd ed. (Washington, DC: Corporate Accountability Research Group, 1981).

Stu Hanigson, "The Oil Drilling Blacklists," Dallas *Times Herald*, Nov. 30, 1981.

Harvey Hilaski, "Understanding Statistics on Occupational Illness," *Monthly Labor Review*, March 1981, pp. 25-9.

Harvey J. Hilaski and Chao Ling Wang, "How Valid are Estimates of Occupational Illness?" *Monthly Labor Review*, August 1982, pp. 27-35.

Interagency Task Force on Workplace Safety and Health, *Making Prevention Pay* (Washington, DC, 1978).

Carol Jones, *Models of Regulatory Enforcement and Compliance, with an Application to the Occupational Safety and Health Administration Asbestos Standard*, unpublished Ph.D. dissertation, harvard University, July 1982.

Trudy Karlson and Susan Baker, "Fatal Occupational Injuries Associated with Motor Vehicles," *Proceedings of the 22nd Conference of the American Association for Automotive Medicine*, 1978, Vol. 1, pp. 229-41.

Max D. Kossoris, "Industrial Injuries and the Business Cycle", *Monthly Labor Review*, March 1938, pp. 579-94.

M. S. Lewis-Beck and J. R. Alford, "Can Government Regulate Safety? The Coal Mine Example," *American Political Science Review* 74:745-56, 1980.

John Mazor, "How Accurate Are Employers' Illness and Injury Reports?" *Monthly Labor Review*, September 1976, pp. 26-31.

David P. McCaffrey, "Work-Related Amputations by Type and Prevalence" *Monthly Labor Review*, March 1981, pp. 35-41.

David P. McCaffrey, "An Assessment of OSHA's Recent Effects on Injury Rates," *Journal of Human Resources*, January 1983.

John Mendeloff, *Regulating Safety*, (Cambridge, Mass.: MIT Press, 1979).

John Mendeloff, *An Analysis of OSHA Inspection Data*, (Working Paper # 2 of *Preventing Illness and Injury in the Workplace*), contract report prepared for Office of Technology Assessment, U.S. Congress, Washington, DC, April 1983.

John Mendeloff, "The Role of OSHA Violations in Serious Workplace Accidents," *Journal of Occupational Medicine* 26(5):353-60, May 1984.

J. Donald Millar, Director, National Institute for Occupational Safety and Health, testimony before the Subcommittee on Manpower and Housing, House Committee on Government Operations, U.S. Congress, *OSHA Injury and Illness Information System*, Hearing, June 20, 1984 (Washington, DC: U.S. Government Printing Office, 1984).

National Safety Council, "This is the National Safety Council," 1980.

National Safety Council, *Accident Facts*, 1981.

National Safety Council, "Documentation of National Safety Council Statistics Department Estimating Procedures for Motor Vehicle, Work, Home, and Public Deaths and Death Rates," memo, February 1982.

G. R. Neumann and J. P. Nelson, "Safety Regulation and Firm Size: Effects of the Coal Mine Health and Safety Act of 1969," *Journal of Law and Economics* 25:183-199, October 1982.

President's Report on Occupational Safety and Health for 1971, May 1972.

Peter W. Ries, "Episodes of Persons Injured: United States, 1975," *Advance Data*, Number 18, March 7, 1978.

Norman Root and David McCaffrey, "Providing More Information on Work Injury and Illness," *Monthly Labor Review*, April 1978, pp. 16-21.

Norman Root and Michael Hoefer, "The First Work-Injury Data Available From New BLS Study" *Monthly Labor Review*, January 1979, pp. 76-80.

Norman Root and Judy R. Daley, "Are Women Safer Workers?" *Monthly Labor Review*, September 1980, pp. 3-10.

Norman Root, "Injuries at Work Are Fewer Among Older Employees," *Monthly Labor Review*, March 1981, pp. 30-34.

Norman Root and Deborah Sebastian, "BLS Develops Measure of Job Risk by Occupation," *Monthly Labor Review*, October 1981, pp. 26-30.

Ruth Ruttenberg, "Compliance with the OSHA Cotton Dust Rule," contract report, March 1983.

Safety Sciences, *Feasibility of Securing Research-Defining Accident Statistics*, (NIOSH Technical Report, NIOSH Pub. No. 78-180, September 1978).

Lyle Schauer and Thomas Ryder, "New Approach to Occupational Safety and Health Statistics," *Monthly Labor Review*, March 1972, pp. 14-19.

Scott Schneider, ""OSHA's Effectiveness: A Rejoinder to McCaffrey," typescript, 1983.

Joel B. Schwartz and Samuel S. Epstein, "Problems in Assessing Risk From Occupational and Environmental Exposure to Carcinogens," in *Banbury Report 9*.

Russell Settle, *Benefits and Costs of the Federal Asbestos Standard*, report prepared for the Office of the Asst. Sec. for Policy, Evaluation, and Research, U.S. Dept. of Labor, Washington, DC, February 1975.

Russell Settle, quoted in *Business War on the Law: An Analysis of the Benefits of Federal Health/Safety Enforcement*, Mark Green and Norman Waitzman, 2nd ed. (Washington, DC: Corporate Accountability Research Group, 1981).

Glenn Shor, "An Analysis of the 1978 Survey of Disability and Work," prepared for the ASPER, U.S. Dept. of Labor, typescript, December 31, 1981.

Robert S. Smith, "Intertemporal Changes in Work Injury Rates," *IRRA Proceedings* (1972), pp 167-74.

Robert S. Smith, *The Occupational Safety and Health Act: Its Goals and Its Achievements*, (Washington, DC: American Enterprise Institute, 1976).

Robert S. Smith, "The Impact of OSHA Inspections on Manufacturing Injury Rates," *Journal of Human Resources*, (14,2) Spring 1979, pp. 145-70.

U.S. Congress, General Accounting Office, *Better Data on Severity and Causes of Worker Safety and Health Problems Should be Obtained from Workplaces* HRD-76-118 (Washington, DC: U.S. Government Printing Office, August 12, 1976).

U.S. Congress, General Accounting Office, *How Can Workplace Injuries Be Prevented? The Answers May be in OSHA Files* HRD-79-43 (Washington, DC: U.S. Government Printing Office, May 3, 1979).

U.S. Congress, House Committee on Education and Labor, *Report No. 91-1291*, July 9, 1970 (Washington, DC: U.S. Government Printing Office, 1970).

U.S. Congress, House Committee on Government Operations, Subcommittee on Manpower and Housing, *OSHA Injury and Illness Information System*, Hearing, June 20, 1984 (Washington, DC: U.S. Government Printing Office, 1984).

U.S. Congress, House Committee on Government Operations, *Occupational Illness Data Collection: Fragmented, Unreliable, and Seventy Years behind Communicable Disease Surveillance*, House Report 98-1144 (Washington, DC: U.S. Government Printing Office, 1984).

U.S. Congress, Office of Technology Assessment, *The Direct Use of Coal*, (Washington, DC: U.S. Government Printing Office, April 1979).

U.S. Congress, Office of Technology Assessment, *Assessment of Technologies for Determining Cancer Risks from the Environment* (Washington, DC: U.S. Government Printing Office, June 1981).

U.S. Congress, Senate Committee on Labor and Public Welfare, *Report No. 91-1282*, October 6, 1970, (Washington, DC: U.S. Government Printing Office, 1970).

U.S. Congress, Senate Committee on Labor and Human Resources, *Occupational Safety and Health Improvements Act of 1980*, Hearings, April 15, 17, and 23, 1980, (Washington, DC: U.S. Government Printing Office, 1980).

U.S. Department of Health and Human Services, National Center for Health Statistics, *Current Estimates from the National Health Interview Survey*, various years.

U.S. Department of Health and Human Services, National Center for Health Statistics, *Persons Injured and Disability Days by Detailed Type and Class of Accident, United States, 1971-72*, January 1976.

U.S. Department of Health and Human Services, National Center for Health Statistics, *Vital Statistics of the U.S., 1977*.

U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH) *National Occupational Hazard Survey* (NOHS) Volumes 1-3, 1977.

U.S. Department of Labor, Assistant Secretary for Policy, Evaluation, and Research (ASPER), *An Interim Report to Congress on Occupational Diseases*, June 1980.

U.S. Department of Labor, Bureau of Labor Statistics, "Comparison of 1974 NSC and BLS Death Estimates," typescript, n.d.

U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Labor Statistics*, 1980.

U.S. Department of Labor, Bureau of Labor Statistics, *Survey of Ladder Accidents Resulting in Injuries*, NTIS Accession No. PB83-207935 (Springfield, VA: National Technical Information Service, 1978).

U.S. Department of Labor, Bureau of Labor Statistics, *Survey of Welding and Cutting Accidents Resulting in Injuries*, NTIS Accession No. PB83-208017 (Springfield, VA: National Technical Information Service, 1978).

U.S. Department of Labor, Bureau of Labor Statistics, *Survey of Scaffold Accidents Resulting in Injuries*, NTIS Accession No. PB83-208009 (Springfield, VA: National Technical Information Service, 1978).

U.S. Department of Labor, Bureau of Labor Statistics, *Survey of Power Saw Accidents Resulting in Injuries*, NTIS Accession No. PB83-207993 (Springfield, VA: National Technical Information Service, 1978).

U.S. Department of Labor, Bureau of Labor Statistics, *Accidents Involving Eye Injuries*, Report 597 (Washington, DC: Government Printing Office, 1980).

U.S. Department of Labor, Bureau of Labor Statistics, *Accidents Involving Face Injuries*, Report 604 (Washington, DC: Government Printing Office, 1980).

U.S. Department of Labor, Bureau of Labor Statistics, *Accidents Involving Head Injuries*, Report 605 (Washington, DC: Government Printing Office, 1980).

U.S. Department of Labor, Bureau of Labor Statistics, *Accidents Involving Foot Injuries*, Report 626 (Washington, DC: Government Printing Office, 1981).

U.S. Department of Labor, Bureau of Labor Statistics, *Injuries Related to Servicing Equipment*, Bulletin 2115 (Washington, DC: Government Printing Office, 1981).

U.S. Department of Labor, Bureau of Labor Statistics, *Back Injuries Associated with Lifting*, Bulletin 2144 (Washington, DC: U.S. Government Printing Office, 1982).

U.S. Department of Labor, Bureau of Labor Statistics, *Work-related Hand Injuries and Upper Extremity Amputations*, Bulletin 2160 (Washington, DC: Government Printing Office, 1982).

U.S. Department of Labor, Bureau of Labor Statistics, *Injuries in Oil and Gas Drilling and Services*, Bulletin 2179 (Washington, DC: Government Printing Office, 1983).

U.S. Department of Labor, Bureau of Labor Statistics, *Injuries Resulting from Falls from Elevations*, Bulletin 2195 (Washington, DC: Government Printing Office, 1984).

U.S. Department of Labor, Bureau of Labor Statistics, *Injuries in the Logging Industry*, Bulletin 2203 (Washington, DC: Government Printing Office, 1984).

U.S. Department of Labor, Bureau of Labor Statistics, *Injuries Resulting from Falls on Stairs*, Bulletin 2214 (Washington, DC: Government Printing Office, 1984).

U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Injuries and Illnesses in the United States by Industry, 1980*, Bulletin 2130, (Washington, DC: U.S. Government Printing Office, April 1982).

U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Injuries and Illnesses in the United States by Industry, 1981*, Bulletin 2164, (Washington, DC: U.S. Government Printing Office, January 1983).

U.S. Department of Labor, Bureau of Labor Statistics, "Occupational Injuries and Illnesses in 1982," typescript, press release, Nov. 4, 1983.

U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Injuries and Illnesses in the United States by Industry, 1982*, Bulletin 2196, (Washington, DC: U.S. Government Printing Office, April 1984).

U.S. Department of Labor, Bureau of Labor Statistics, "Occupational Injuries and Illnesses in 1983," typescript, press release, Nov. 14, 1984.

U.S. Department of Labor, Occupational Safety and Health Administration, "Recordkeeping Requirements under the Occupational Safety and Health Act of 1970," revised 1978.

U.S. Department of Labor, Occupational Safety and Health Administration, *Benefits Analysis for the Proposed Federal Standard Regulating [illegible]*, 1980.

U.S. Department of Labor, Occupational Safety and Health Administration, *Occupational Safety and Health Statistics of the Federal Government, CY 1979*, (OSHA 2066, January 1981).

U.S. Department of Labor, Occupational Safety and Health Administration, Instruction CPL 2.25B, October 1, 1981.

U.S. Department of Labor, Occupational Safety and Health Administration, *Regulatory Impact and Regulatory Flexibility Assessment of the Proposed Standard on Servicing Single-Piece Rim Wheels*, September, 1982.

U.S. Department of Labor, Occupational Safety and Health Administration, Division of Statistical Studies and Analysis, "Occupational Fatalities Among Workman's Compensation Claims, 1972," xerox, n.d.

U.S. Department of Labor, Occupational Safety and Health Administration, Division of Statistical Studies and Analysis, "A Comparison of Occupational Injury Rates," xerox, February 1978.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Occupational Fatalities related to Fixed Machinery as found in Reports of OSHA Fatality/Catastrophe Investigations*, May 1978.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Occupational Fatalities related to Scaffolds as found in Reports of OSHA Fatality/Catastrophe Investigations*, May 1979.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Occupational Fatalities related to Ladders as found in Reports of OSHA Fatality/Catastrophe Investigations*, November 1979.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Selected Occupational Fatalities related to Roofs, Ceilings and Floors as found in Reports of OSHA Fatality/Catastrophe Investigations*, November 1979.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Selected Occupational Fatalities related to Oil/Gas Well Drilling Rigs as found in Reports of OSHA Fatality/Catastrophe Investigations*. June 1980.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Occupational Fatalities related to Miscellaneous Working Surfaces as found in Reports of OSHA Fatality/Catastrophe Investigations*, April 1982.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Selected Occupational Fatalities related to Fire and/or Explosion in Confined Work Spaces as found in Reports of OSHA Fatality/Catastrophe Investigations*, April 1982.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Selected Occupational Fatalities related to Lockout/Tagout Problems as found in Reports of OSHA Fatality/Catastrophe Investigations*, August 1982.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Selected Occupational Fatalities related to Grain Handling as found in Reports of OSHA Fatality/Catastrophe Investigations*, January 1983.

U.S. Department of Labor, Occupational Safety and Health Administration, Office of Statistical Studies and Analysis, *Selected Occupational Fatalities related to Powered, Two-Oint Suspension Scaffolds/Powered Platforms as found in Reports of OSHA Fatality/Catastrophe Investigations*, March 1983.

Viscusi, W. K., "The Impact of Occupational Safety and Health Regulation," *Bell Journal of Economics* 10(1):117-40, Spring 1979.

Warner, K. E., *Technology and Handicapped People/ Background Paper # 1: Mandatory Passive Restraint Systems in Automobiles* prepared by the Office of Technology Assessment, U.S. Congress (Washington, DC: U.S. Government Printing Office, September 1982).

Weeks, J. L., and Fox, M., "Fatality Rates and Regulatory Policies in Bituminous Coal Mining, United States, 1959-81," *American Journal of Public Health* 73(11):1278-1280, November 1983.

Whiting, B., Deputy Assistant Secretary for Occupational Safety and Health, testimony before the Senate Committee on Labor and Human Resources, U.S. Congress, March 21, 1980.

TABLE 1: National Safety Council,
Deaths and Death Rates for Occupational Injuries, 1933-

Year	Total			
	Work-Related			
	Work-Related Deaths	Motor Vehicle Deaths[1]	Workers (thousands)	Rate[2]
1933	14,500		39,000	37
1934	16,000		41,500	39
1935	16,500		42,500	39
1936	18,500		44,000	42
1937	19,000		44,100	43
1938	16,000		42,100	38
1939	15,500		43,600	36
1940	17,000		45,200	38
1941	18,000		48,100	37
1942	18,000		51,500	35
1943	17,000		52,200	34
1944	16,000		51,800	31
1945	16,500		50,200	33
1946	16,500		52,400	31
1947	17,000	2,500	54,900	31
1948	16,000	2,100	56,000	29
1949	15,000	2,200	55,200	27
1950	15,500	2,700	56,400	27
1951	16,000	2,800	57,450	28
1952	15,000	2,800	57,800	26
1953	15,000	3,100	58,050	26
1954	14,000	2,800	57,500	24
1955	14,200	3,000	59,400	24
1956	14,300	3,000	61,100	23
1957	14,200	2,900	61,300	23
1958	13,300	2,600	59,900	22
1959	13,800	2.800	61,300	23
1960	13,800	2,800	64,400	21
1961	13,500	2,600	64,500	21

Table 1 (cont.)

	Total			
Year	Work-Related Deaths	Work-Related Motor Vehicle Deaths[1]	Workers (thousands)	Rates[2]
1962	13,700	2,700	65,200	21
1963	14,200	3,000	66,200	21
1964	14,200	3,100	67,600	21
1965	14,100	3,000	69,700	20
1966	14,500	3,200	72,600	20
1967	14,200	3,200	74,700	19
1968	14,300	3,600	76,900	19
1969	14,300	3,600	79,000	18
1970	13,800	3,700	77,700	18
1971	13,700	4,200	78,200	18
1972	14,000	4,300	80,900	17
1973	14,300	4,500	83,700	17
1974	13,500	4,000	85,400	16
1975	13,000	3,900	84,100	15
1976	12,500	4,100	86,900	14
1977	12,900	4,300	90,000	14
1978	13,100	4,500	93,800	14
1979	13,300	4,500	96,500	14
1980	13,000	4,500	96,800	13
1981	12,100	4,400	99,800	12
1982	11,100	4,000	98,800	12
1983	11,300	4,100	100,100	11

Source: National Safety Council, Accident Facts

1. Work-related motor vehicle deaths are included in the number of work-related deaths.

2. Deaths per 100,000 workers.

Table 2
BLS Estimates of Occupational Fatalities,[1]
Private Sector

	Fatalities (Number)		
Year	All private	11+ employees	Rate[4]
1973	5700	5340	N.A.
1974	5900	4970	9.8
1975	5200[2]	4570	9.4
1976	4500[2]	3940	7.9
1977	N.A.[3]	4760	9.1
1978	N.A.[3]	4590	8.2
1979	N.A.[3]	4950	8.6
1980	N.A.[3]	4400	7.7
1981	N.A.[3]	4370	7.6
1982	N.A.[3]	4090	7.4
1983	N.A.[3]	3100	5.6

Source: BLS, Occupational Injuries & Illnesses, Various Years

1. Injuries and Illnesses. About 11% are due to heart attacks.

2. Excludes farms with fewer than 11 employees, comparable estimate for 1975 including those farms is 5300.

3. For 1977, in order to comply witha Presidential Directive on the reduction of paperwork. The sample was reduced by 85,000 units, affecting primarily employers with fewer than 11 employees. Because of this reduction, year to year comparisons of fatalities for small employers are statistically unreliable. The average number of fatalities for these small employers in 1974-78 was 900. For 1979-83 it was 1,040.

4. Deaths per 100,000 full-time equivalent employees.

Table 3
National Safety Council,
Disabling Injuries

Year	Disabling Injuries On-Job	Rate[1]
1945	2,000,000	4.0
1950	1,950,000	3.5
1955	1,950,000	3.3
1960	1,950,000	3.0
1965	2,100,000	3.0
1966	2,200,000	3.0
1967	2,200,000	2.9
1968	2,200,000	2.9
1969	2,200,000	2.8
1970	2,200,000	2.8
1971	2,300,000	2.9
1972	2,400,000	3.0
1973	2,500,000	3.0
1974	2,300,000	2.7
1975	2,200,000	2.6
1976	2,200,000	2.5
1977	2,300,000	2.6
1978	2,200,000	2.3
1979	2,300,000	2.4
1980	2,200,000	2.3
1981	2,100,000	2.1
1982	1,900,000	1.9
1983	1,900,000	1.9

Source: National Safety Council, Accident Facts,

1. Injuries per 100 workers. Number of workers is from Table 1.

Table 4
Occupational Injuries
Private Sector

Year	Total Recordable Cases[1] (thou)	Lost Workday Cases (thou)	Nonfatal Cases w/o Lost Workdays (thou)	Lost Workdays (thou)
1973	5,837.6	1,830.7	4,001.8	28,156.1
1974	5,715.4	1,941.0	3,769.3	30,288.8
1975	4,828.0	1,772.6	3,050.5	29,820.3
1976[2]	4,995.8	1,918.1	3,073.5	32,457.8
1977[2]	5,298.5	2,146.8	3,145.9	35,234.4
1978[2,3]	5,656.0	2,438.5	3,212.5	38,173.9
1979[2,3]	5,956.8	2,701.4	3,250.4	42,636.9
1980[2]	5,475.6	2,491.0	2,979.8	40,894.9
1981[2]	5,278.4	2,408.9	2,864.9	39,199.3
1982[2]	4,751.0	2,141.3	2,604.5	36,114.1
1983[2,3]	4,748.0	2,140.3	2,604.5	36,373.5

Source: BLS, *Occupational Injuries & Illnesses in the U.S.*, Various Years.

1. Includes fatalities.
2. Excludes farms with fewer than 11 employees.
3. Statistical method used to generate estimates for small nonfarm employers in low-risk industries.

Table 5
Occupational Illnesses
Private Sector

Year	Total Recordable Cases[1] (thou)	Lost Workday Cases (thou)	Nonfatal Cases w/o Lost Workdays (thou)	Lost Workdays (thou)
1973	200.5	58.5	141.6	827.0
1974	200.4	60.8	138.9	881.1
1975	163.8	54.9	108.5	885.2
1976[2]	167.9	60.7	106.9	1490.5
1977[2]	161.9	56.8	104.7	906.0
1978[2,3]	143.5	53.5	89.5	841.4
1979[2,3]	148.9	56.4	92.0	939.6
1980[2,3]	130.2	48.9	80.6	922.0
1981[2]	126.1	48.6	76.9	851.6
1982[2]	105.6	41.2	64.1	761.1
1983[2,3]	106.1	42.4	63.1	827.9

Source: BLS, Occupational Injuries & Illnesses in the U.S., Various Years.

1. Includes fatalities.

2. Excludes farms with fewer than 11 employees.

3. Statistical method used to generate estimates for small nonfarm employers in low-risk industries.

Table 6
Federal Employee Injuries and Illnesses

Civilian Personnel

Calendar Year	Total Cases			Lost Workday Cases			Total Number of Lost Workdays
	Total	Injuries	Illnesses	Total	Injuries	Illnesses	
1976	174,989	169,425	5,564	80,891	79,243	1,648	1,366,001
1977	182,781	176,713	6,068	90,275	88,319	1,956	1,480,958
1978	184,868	179,942	4,926	93,572	92,048	1,524	1,448,429
1979	190,353	184,744	5,609	96,230	94,446	1,784	1,459,140
1980	187,042	182,034	5,008	93,801	92,302	1,499	1,336,855
1981	175,312	170,305	5,007	87,186	85,561	1,625	1,257,090
1982	168,426	164,021	4,405	85,106	83,652	1,454	1,244,487

Source: OSHA, Occupational Safety and Health Statistics of the Federal Government, various years.

Table 7
Injuries While At Work
From the National Health Interview Survey

Year	Number Injured (thou)	Restricted Activity Days (thou)	Bed Disability Days (thou)	Number Currently Employed (thou)
62-63	7,356	96,647	22,185	67,954
63-64	8,630	122,154	28,705	70,122
64-65	8,993	126,672	32,241	70,465
65-66	9,375	154,683	37,412	73,123
66-67	10,304	159,680	37,608	74,937
1967	9,203	143,389	33,943	75,256
1968	9,287	145,955	31,175	75,931
1969	8,241	121,574	23,949	76,979
1970	7,750	110,947	26,798	77,655
1971	9,631	120,384	30,122	77,407
1972	7,938	102,247	24,131	80,244
1973	9,027	124,692	32,212	83,441
1974	9,254	144,191	38,143	84,307
1975	9,841	138,838	36,248	83,218
1976	9,292	140,590	35,272	87,119
1977	11,414	160,533	37,351	90,838
1978	10,511	184,031	42,593	93,107
1979	12,014	176,284	40,707	96,616
1980	10,826	184,636	42,657	97,511
1981	11,291	214,873	43,957	100,324

Source: 1962-1981 — Current Estimates from the National Health Interview Survey (Various Years)

Table 8
Health Interview Survey,
Persons Injured, 1980

Class of Accident	Number Injured (thou)	Days of Restricted Activity (thou)	Days of Bed Disability (thou)	Days per Injury Restricted Activity	 Bed Disability
All Classes	68,089	778,949	193,378	11.44	2.84
Moving Motor Vehicle	4,392	145,432	36,850	33.11	8.39
While at Work	10,826	184,636	42,657	17.05	3.94
Home	26,693	187,958	53,176	7.04	1.99
Other	28,211	300,578	69,881	10.65	2.48

Source: NCHS, *Current Estimates from the National Health Interview Survey, U.S.*, 1980, Tables 9, 10, & 11.

Table 9
Occupational Injury and Illness Fatalities and Employment With 11 Employees or More by Industry Division, 1980

Industry Division	Annual Average Employment Number (thou)	Annual Average Employment Percent	Fatalities Number (thou)	Fatalities Percent
Private sector..........	61,677	100	4,400	100
Agriculture, forestry, and fishing..........................	943	2	140	3
Mining........................	944	2	460	10
Construction........................	3,141	5	830	19
Manufacturing........................	19,630	32	1,080	25
Transportation and public utilities........................	4,665	8	810	18
Wholesale and retail trade........	14,474	23	580	13
Finance, insurance and real estate........................	4,078	7	150	3
Services........................	13,802	22	350	8

Source: BLS, Occupational Injuries & Illnesses in the U.S.

Note: Because of rounding, components may not add to the totals.

Table 10
Causes of Fatalities Resulting from Occupational Injury and Illness
in 1979 and 1980[1]
in Units with 11 Employees or More,
Private Sector,
by Industry Division, Distribution by Industry

CAUSE[2]	TOTAL[3]	Agriculture Forestry and Fishing	Mining -- Oil and Gas Extraction Only	Construction	Manufacturing	Transportation and public utilities[4]	Wholesale and retail trade	Finance insurance and real estate	Services
Total--all causes......	100	100	100	100	100	100	100	100	100
Over-the-road motor vehicles....................	30	28	21	16	18	46	48	53	29
Heart attacks...............	11	15	10	9	9	9	14	24	16
Industrial vehicles or equipment.................	10	20	20	15	12	5	2	4	8
Falls.......................	9	4	9	22	9	4	2	5	8
Electrocutions..............	8	5	15	12	6	9	3	1	9
Aircraft crashes............	5	6	10	1	4	11	4	11	3
Struck by objects other than vehicles or equipment......	5	8	5	8	8	4	2	1	1
Plant machinery operations..	4	2	1	1	12	1	2	0	2
Gun shots...................	4	1	0	(5)	1	3	17	1	6
Caught in, under, or between objects other than vehicles or equipment......	3	1	1	6	4	1	1	0	(5)
Fires.......................	3	5	2	1	6	2	2	0	2
Explosions..................	2	2	2	3	4	1	1	0	(5)
Gas inhalations.............	2	2	1	2	4	1	(5)	0	1
All other...................	4	2	4	3	4	4	3	1	16

1. It is impossible to estimate year-to-year changes precisely because at the industry division level sampling errors are large. Therefore, the results are for both years rather than a comparison between then.
2. Cause is defined as the object or event associated with the fatality.
3. Excludes coal, metal and nonmetal mining, and railroads for which data are not available.
4. Excludes railroads.
5. Less than 1 percent.

NOTE: Because of rounding, percentages may not add to 100.

Source: BLS, Occupational Injuries and Illnesses, 1980, p.33.

Table 11

Causes of Fatalities Resulting from Occupational Injury and Illnesses in 1979 and 1980[1] in Units with 11 Employees or More, Private Sector, by Industry Division, Distribution by Cause

(In percent)

CAUSE[2]	TOTAL[3]	Agriculture Forestry and Fishing	Mining -- Oil and Gas Extraction Only	Construction	Manufacturing	Transportation and public utilities[4]	Wholesale and retail trade	Finance insurance and real estate	Services
Over-the-road motor vehicles	100	3	4	11	16	28	26	5	7
Heart attacks..............	100	4	5	17	22	15	21	6	11
Industrial vehicles or equipment..............	100	6	11	30	33	9	4	1	6
Falls....................	100	1	6	48	27	7	3	2	7
Electrocutions..............	100	2	11	30	22	20	7	(5)	9
Aircraft crashes............	100	4	11	5	19	40	11	6	5
Struck by objects other than vehicles or equipment......	100	5	6	28	40	13	8	(5)	1
Plant machinery operations..	100	1	1	6	79	2	8	0	3
Gun shots..................	100	(5)	0	1	7	11	70	1	11
Caught in, under, or between objects other than vehicles or equipment......	100	1	2	47	40	5	5	0	1
Fires......................	100	5	5	6	56	13	11	0	5
Explosions..................	100	2	4	28	47	12	7	0	1
Gas inhalation..............	100	3	2	22	59	7	3	0	5
All other..................	100	2	5	12	24	16	12	1	29

1. It is impossible to estimate year-to-year changes precisely because at the industry division level sampling errors are large. Therefore, the results are for both years rather than a comparison between them.
2. Cause is defined as the object or event associated with the fatality.
3. Excludes coal, metal and nonmetal mining, and railroads for which data are not available.
4. Excludes railroads.
5. Less than 1 percent.

Note: Because of rounding, percentages may not add to 100.

Source: BLS, Occupational Injuries & Illnesses, 1980, p.33.

Table 12
Fatal Occupational Injuries in Maryland, 1978

Type of Event	Number	Percent
Total	148	100
Road vehicle	37	25
Nonroad vehicle	23	16
Shooting	16	11
Boat	16	11
Fall from Height	13	9
Airplane	7	5
Fixed Machinery	8	5
Other	28	19

Source: Baker, et al.

Table 13
Occupational Injuries and Illnesses by Industry Division, 1980

Industry Division	Total Cases		Lost Workday Cases		Nonfatal Case Without Lost Workdays		Lost Workdays	
	Number (thou)	Rate[1]	Number (thou)	Rate[1]	Number (thou)	Rate[1]	Number (thou)	Rate[1]
Private Sector......................	5,505.8	8.7	2,539.9	4.0	3,060.4	4.7	41,816.9	65.2
Agriculture, forestry and fishing..	83.5	11.9	40.4	5.8	42.9	6.1	578.8	82.7
Mining.............................	114.9	11.2	66.9	6.5	47.6	4.6	1,683.0	163.6
Construction.......................	588.1	15.7	245.2	6.5	341.8	9.1	4,385.5	117.0
Manufacturing......................	2,354.2	12.2	1,038.7	5.4	1,314.4	6.8	16,745.8	86.7
Transportation and public utilities	452.8	9.4	266.5	5.5	185.4	3.8	5,044.7	104.5
Wholesale and retail trade.........	1,210.8	7.4	526.0	3.2	684.0	4.2	7,931.7	48.7
Finance, insurance and real estate	89.6	2.0	38.8	0.8	50.5	1.1	558.6	12.2
Services...........................	711.7	5.2	317.4	2.3	393.8	2.9	4,888.8	35.8

1. Incidence rate per 100 full-time workers

2. Excludes farms with fewer than 11 employees.

Source: BLS, Occupational Injuries and Illnesses in the U.S., 1980, Tables 1 and 2.

Table 14
Occupational Injury Incidence Rates
by Employment Size,
Private Sector
1980

Employment Size	Incidence Rates per 100 Full-Time Workers[1]
1-19 employees	3.6
20-49 employees	8.3
50-99 employees	10.9
100-249 employees	12.1
250-499 employees	11.7
500-999 employees	9.9
1,000-2,499 employees	8.0
2,500 employees or more	6.5

Source: BLS, Occupational Injuries & Illnesses in the U.S., 1980, p. 29.

[1] Total Case Rate for all recordable injuries. Private sector average for 1980 equals 8.5.

Table 15

Sources of Injury and Associated Objects or Substances

	Source of Injury[1]		A.O.S.[2]	
Percent	Disability[3] States	Medical Treatment[4] States	Disability[5] States	Medical Treatment[6] States
TOTAL	100.0	100.0	100.0	100.0
Animals, insects	.5	1.0	.9	.9
Animal products	.1	.2	.1	.2
Bodily motion	7.5	3.8	.2	1.4
Boilers, pressure vessels	.4	.5	.9	1.1
Boxes, barrels, containers	12.4	8.6	12.8	9.3
Buildings and structures	2.3	2.5	2.7	2.7
Ceramic Items	.3	.2	.2	.2
Chemicals	1.5	2.2	1.2	1.5
Clothing	.1	.2	.4	.3
Coal and petroleum products	.5	.4	.2	.3
Cold	.1	—	.1	—
Conveyors	.5	.4	.5	.5
Electric Apparatus	.9	.9	1.1	1.2
Excavations, trenches, tunnels	N.A.	N.A.	.1	.1
Flame, fire, smoke	.5	.5	.2	.2
Food products	.9	.9	.8	.8
Furniture, fixtures, etc.	3.2	3.0	4.7	3.2
Glass Items, NEC	.8	1.6	.6	1.1
Hand tools, not powered	4.8	8.1	5.9	9.5
Powered hand tools	1.5	2.0	2.0	4.1
Heat (environmental)	.1	.1	.1	—
Heating equipment	.4	.4	.6	.7
Hoisting apparatus	.8	.7	1.0	1.0
Infectious/parasite agents	.3	.1	.4	—
Ladders	.3	.4	1.6	1.3
Liquids, NEC	.5	.7	.2	.2
Machines	7.1	5.6	7.2	9.0
Mechanical power transmission apparatus	0.3	.5	.2	.7
Metal items	11.3	15.8	7.6	10.4
Mineral items	0.8	1.5	.6	1.1
Noise	.1	.1	—	—

Table 15 (cont.)

Percent	Source of Injury[1] Disability[3] States	Source of Injury[1] Medical Treatment[4] States	A.O.S.[2] Disability[5] States	A.O.S.[2] Medical Treatment[6] States
Paper and pulp	.3	.2	.3	.3
Particles (unidentified)	1.0	3.1	.7	2.1
Plants, trees, vegetation	.6	.6	.8	.6
Plastic items, NEC	.2	.2	.1	.1
Pumps and prime movers	.3	.3	.3	.3
Radiating substances and equipment	.3	.6	.1	.2
Soaps, detergents, etc	.2	.4	.3	.3
Scrap, debris, waste materials	.1	--	.1	.1
Steam	.1	.1	--	--
Textile items, NEC	.1	.1	.2	.2
Vehicles	8.2	6.0	11.4	7.9
Highway vehicles	3.0	3.4	6.7	4.6
Plant or industrial vehicles	3.0	2.1	3.6	2.5
Wood items	3.3	5.0	3.0	5.6
Working surfaces	14.6	11.5	13.5	10.5
Person	4.1	3.0	8.5	3.8
Piles, stacks	N.A.	N.A.	.4	.4
Recreation and athletic equipment	.2	.2	.3	.2
Rubber products	.5	.5	.5	.5
Miscellaneous	1.3	2.4	1.2	1.3
Nonclassifiable, unknown	3.8	2.6	3.1	2.7

---

1. The object, substance, or bodily motion which directly produced or inflicted the injury or illness.
2. The object, substance, or person with respect to which measures could have been introduced to prevent the accident or mitigate the injury or illness.
3. Data from 18 States providing only cases with days of disability (the number in parentheses in the minimum number of days of disability required for inclusion): Alaska (1), Arizona (8), California (1), Colorado (4), Indiana (1), Iowa (4), Kentucky (2), Maryland (4), Massachusetts (1), Michigan (7), Minnesota (3), Mississippi (6), New Jersey (1), New Mexico (8), Ohio (1), Oregon (4).
4. Data from 11 States providing cases with days of disability or medical treatment. This table contains data from Hawaii, Idaho, Maine, Missouri, Montana, Nebraska, Utah, Vermont, Virgin Islands, Washington, and Wyoming.
5. Data from 6 States providing only cases with days of disability (the number in parentheses is the minimum number of days of disability required for inclusion): California (1), Colorado (4), Iowa (4), Maryland (4), Minnesota, (3), and New Mexico (8). The minimum number of days of disability before a report of a case is included in the supplementary data system is indicated in parentheses after each state.
6. Data from 4 States providing cases with days of disability or medical treatment: Maine, Utah, Vermont, and Washington.

Source: SDS, 1980, Tables 103 and 105.

Table 16
Type of Accident or Exposure

Type	Disability States Cases	%	Medical Treatment States Cases	%
TOTAL	1,101,466	100.0	646,764	100.0
Struck against	100,061	9.1	90,790	14.0
Struck by	190,931	17.3	157,202	24.3
Fall from Elevation	75,812	6.9	38,523	6.0
Fall on Same Level	106,274	9.6	51,393	7.9
Caught in, under, between	74,987	6.8	45,978	7.1
Rubbed or Abraded	30,147	2.7	45,357	7.0
Bodily Reaction	84,106	7.6	24,806	3.8
Overexertion	297,121	27.0	120,316	18.6
Contact with Electricity	2,090	.2	1,130	.2
Contact with Temperature Extremes	26,771	2.4	18,195	2.8
Contact with Radiations, Caustics	35,913	3.3	28,449	4.4
Transportation Accident (Non Motor Vehicle)	673	.1	169	--
Motor Vehicle Accident	27,657	2.5	8,982	1.4
Noise Exposure	610	.1	483	.1
Explosives	2,602	.2	784	.1
N.E.C	10,945	1.0	3,083	.5
Nonclassifiable	34,766	3.2	11,124	1.7

Source: SDS, 1980, Table 104, unpublished compilation.

Table 17
Nature of Injury or Illness

Nature of Injury or Illness	Disability Cases[3] Number	Disability Cases[3] Percent	Medical Treatment Cases[4] Number	Medical Treatment Cases[4] Percent
TOTAL	1,101,466	100.0	646,764	100.0
Amputation/enucleation	7,349	.7	1,589	.2
Asphyxia, drowning, suffocation	144	--	237	--
Burn (heat)	27,453	2.5	17,891	2.8
Burn (chemical)	8,098	.7	9,522	1.5
Concussion	4408	.4	1,650	.3
Infective/parasitic Disease	1,895	.2	482	.1
Contusion, crushing, bruise	124,667	11.3	100,277	15.5
Cut, laceration, puncture	146,377	13.3	149,629	23.1
Dermatitis	9,064	.8	6,835	1.1
Dislocation	13,565	1.2	6,888	1.1
Electric shock/electrocution	1,165	.1	718	0.1
Fracture	94,558	8.6	31,278	4.8
Hearing loss	1,147	.1	606	.1
Effects of environmental heat	966	.1	603	.1
Hernia, rupture	17.610	1.6	3,717	.6
Inflammation of joints/muscles	13,769	1.3	5.414	.8
Poisoning, systemic	7,743	.7	6,384	1.0
Pneumoconiosis	1,318	.1	137	—
Radiation effects	2,995	.3	3,789	.6
Welders flash	2,778		3,687	
Scratches, abrasions	32,189	2.9	60,206	9.3
Sprains, strains	432,144	39.2	186,555	28.8
Hepatitis	703	.1	76	—
Multiple Injuries	26,822	2.4	9,720	1.5
Cerebrovascular/circulatory system	1,677	.2	113	—
Eye diseases	3,710	.3	298	--
Mental disorders	2,030	.2	209	—
Neoplasm, tumor	220	--	14	—
Nervous system conditions	2,027	.2	308	.1
Respiratory system conditions	1,177	.1	83	--
Occupational disease, NEC	905	.1	375	.1
Heart conditions	3529	.3	361	.1
Other[1]	(2)		10,484[1]	1.6
Nonclassifiable	100,528	9.1	30,244	4.7

Table 17 (cont.)

1. Other includes effects of low temperature exposure (211), hemorrhoids (117), atmospheric pressure change effects (176), medical care complications (20), symptoms and ill-defined conditions (671), no injury or illness (183), damage to prosthetic devices (6,194), other injury, NEC (2,912).

2. Low temperature (257), hemorrhoids (416), atmospheric pressure change effects (463), medical care complications (47), syptoms and ill-defined conditions (3,472), no injury or illness (60), damage to prosthetics (94), other injury, NEC (4,705).

3. 18 states

4. 11 states

Source: SDS, 1980, Table 101

Table 18
Part of Body Affected

Part of Body	Disability States		Medical Treatment States	
	Number	%	Number	%
TOTAL	1,101,466	100.0	646,764	100.0
Head	84,158	7.6	109,507	16.9
Eye	44,463	4.0	73,302	11.3
Neck	13,832	1.3	7,835	1.2
Upper Extremities	286,011	26.0	220,646	34.1
Finger	134,174	12.2	117,882	18.2
Trunk	371,778	33.8	148,286	22.9
Back	256,843	23.3	98,275	15.2
Lower Extremities	227,925	20.7	108,206	16.7
Multiple Parts	82,774	7.5	34,173	5.3
Body System	23,648	2.1	10,213	1.6
Not Elsewhere Classified and Nonclassifiable	11,340	1.0	7,898	1.2

Source: SDS, 1980, Table 1Q2, unpublished compilation.

Table 19
Occupational Injury and Illness Rates
Private Sector

	Injuries and Illnesses				Injuries				
	Total cases[1]	Lost workday cases[1]	Nonfatal cases without lost workdays[1]	Lost workdays[1]	Total cases[1]	Lost workday cases[1]	Nonfatal cases without lost workdays[1]	Lost workdays[1] case	Average lost workday per lost workday case
1972[2]........	10.9	3.3	7.6	47.9	10.5	3.2	7.3	46.3	14
1973.........	11.0	3.4	7.5	53.3	10.6	3.3	7.3	51.2	15
1974.........	10.4	3.5	6.9	54.6	10.0	3.4	6.6	53.1	16
1975.........	9.1	3.3	5.8	56.1	8.8	3.2	5.6	54.6	17
1976.........	9.2	3.5	5.7	60.3	8.9	3.4	5.5	57.8	17
1977[4].......	9.3	3.8	5.5	61.6	9.0	3.7	5.3	60.0	16
1978[3,4]......	9.4	4.1	5.3	63.5	9.2	4.0	5.2	62.1	16
1979[3,4]......	9.5	4.3	5.2	67.7	9.2	4.2	5.0	66.2	16
1980[3].......	8.7	4.0	4.7	65.2	8.5	3.9	4.6	63.7	16
1981[3].......	8.3	3.8	4.5	61.7	8.1	3.7	4.4	60.4	16
1982[3].......	7.7	3.5	4.2	58.7	7.6	3.4	4.1	57.5	17
1983[3,4]......	7.6	3.4	4.2	58.5	7.5	3.4	4.1	57.2	N.A.

Source: BLS, "Occupational Injuries and Illnesses in 1983," press release, November 14, 1984, Table 2.

1. Incidence rate per 100 full-time workers

2. Does not include agricultural production, railroads, and most mining operations.

3. Excludes farms with fewer than 11 employees.

4. Statistical method used to generate estimates for small nonfarm employers in low-risk industries.

Table 20

Comparison of the Supplementary Data System and Annual Survey
States Reporting Disability Cases

State	Type of Case Reported to SDS[1]	BLS-Annual Survey Cases with Days Away From Work 1978	1979	1980	BLS-SDS Cases Reported 1978	1979	1980	Ratio: SDS/Annual Survey 1978	1979	1980
Alaska.........	1 or more lost workdays	N.A.	4,659	5,105	N.A.	5,097	6,438[7]	N.A.	1.09	1.26
California.....	1 or more lost workdays	299,632	322,712	314,084	297,578	324,191	313,790	.99	1.00	1.00
Massachusetts..	1 or more lost workdays[2]	31,305	35,944	36,340	N.A.	25,028	31,051	N.A.	.70	.85
Indiana........	more than one lost workday[3]	56,320	59,046	49,257	40,600	41,231	36,060	.72	.70	.73
Kentucky.......	more than one lost workday	34,405	35,970	33,180	46,533	50,567	33,383	1.35	1.41	1.01
Iowa...........	1978-79: 2 or more lost workdays 1980: 3 or more lost workdays	30,261	32,567	28,339	18,076	18,480	23,004	.60	.57	.81
Minnesota......	3 or more lost workdays[4]	47,040	53,043	46,521	47,229	55,170	46,836[7]	1.00	1.04	1.01
Maryland.......	4 or more lost workdays	39,386	44,815	40,628	25,621	28,411	23,363	.65	.63	.57
Oregon.........	4 or more lost workdays[5]	46,577	48,425	42,073	43,662	40,999	40,934	.94	.85	.97
Michigan.......	7 or more lost workdays	92,322	95,166	71,934	67,324	71,510	56,479	.73	.75	.78
Arizona........	1979: 7 or more lost workdays 1980: 8 or more lost workdays	27,020	32,204	28,306	N.A.	17,402	18,031	N.A.	.54	.64
New Mexico.....	8 or more lost workdays	10,703	12,270	11,352	3,752	3,749	4,751	.35	.31	.41
Tennessee......	8 or more lost workdays[6]	46,501	44,696	41,007	27,491	28,757	27,153	.60	.64	.66

Source: BLS, Annual Survey and Supplementary Data System, unpublished data.

1. All States include occupational fatalities.
2. Massachusetts reports only manufacturing cases.
3. 1980 definition is "lost worktime beyond the day of injury."
4. Includes permanent disability cases in 1978.
5. For 1980, includes cases with 1 to 3 lost workdays if they also also involved employee hospitalization.
6. For 1978, includes cases of permanent partial disability
7. Preliminary Data.

Table 21
Duration of Disability for Temporary Total Disability Accidents

Disability Period	Cases[1]	Percent
1 or more days	103,371	100.0
2 or more days	94,398	91.3
3 or more days	86,200	83.4
4 or more days	79,964	77.4
5 or more days	72,887	70.5
6 or more days	66,450	64.3
7 or more days	61,294	59.3
8 or more days	56,440	54.6

Source: National Council of Compensation Insurance (NCCI)

1. Cases closed in 1974 and reported to NCCI in their "Special Call for Accident Statistics" issued in June 1974. Forty-one insurance companies responded.

Table 22

Comparison of the Supplementary Data System and Annual Survey
States Reporting Medical Treatment Cases

State	Type of Case Reported to SDS[1]	BLS Annual Survey: Total Recordable Cases			Supplementary Data System: Cases Reported[2]			Ratio SDS/Annual Survey		
		1978	1979	1980	1978	1979	1980	1978	1979	1980
Hawaii.......	≥ 1 lost workdays or medical treatment	26,400	27,000	29,000	33,577	37,423	41,867	1.27*	1.39*	1.43*
Idaho........	≥ 1 lost workdays or medical treatment	22,600	22,600	19,300	38,273	38,448	33,482	1.69*	1.70*	1.73*
Maine........	≥ 1 lost workdays or medical treatment	32,200	34,500	34,100	40,972	45,119	46,101	1.27*	1.31*	1.35*
Montana......	≥ 1 lost workdays or medical treatment	17,400	18,100	14,100	N.A.[3]	31,473	30,089	N.A.	1.74*	2.13*
Vermont......	≥ 1 lost workdays or medical treatment	12,400	13,800	13,300	18,539	20,416	19,317	1.50*	1.48*	1.45*
Utah.........	1978-79: medical treatment 1980: ≥ 1 lost workdays or medical treatment	37,600	39,800	35,700	24,409	29,345	24,667	.65	.74	.69*
Wyoming......	1978, 1979: medical treatment 1980: ≥ 1 lost workdays or medical treatment	13,600[4]	12,800	12,400	19,053	21,851	23,041	1.40	1.71	1.86*
Nebraska.....	1978, 1979: lost work, medical treatment, or first aid 1980: ≥ 1 lost workdays or medical treatment	40,300[4]	41,800	38,300	32,518	61,276	58,613	.81	1.47	1.53*
Missouri.....	1978-79: received during year 1980: permanent disability, ≥ 1 lost workdays or medical treatment	128,600	133,200	119,300	123,931	136,682	114,097	.96	1.02	.96*
Virgin Islands....	1978-79: received during year 1980: ≥ 1 lost workdays, medical treatment, or first aid	900	1,100	1,000	1,146	1,333	1,123	1.27	1.21	1.12*
Washington...	1978-79: received during year 1980: mixture of current and closed cases	113,400	115,200	106,400	196,731	211,875	190,865	1.73	1.84	N.A.
South Dakota.	1978-79: occurred during year	12,800	12,600	N.A.	16,296	16,814	N.A.	1.27	1.33	N.A.
Alaska.......	1978: lost workdays or medical treatment	9,700	9,700	10,600	18,123	N.A.	N.A.	1.87*	N.A.	N.A.

Source: BLS, Annual Survey and Supplementary Data System, unpublished data.

* Years for which comparisons are possible. See text.

1. All States include occupational fatalities.
2. Because the Annual Survey covers only private sector employers, public sector cases reported by most States to the SDS have been excluded.
3. Montana submitted a mixture of current and closed cases in 1978.
4. Occurred during year and involve death, medical treatment beyond first aid, loss of consciousness, restriction of work or motion, or transfer to another job.

Table 23
Work Injury Rates from the BLS Annual Survey and the National Health Interview Survey

Year	BLS Total Case Rate[1]	BLS Recordable Injury Rate[2]	National Health Interview Survey		
			Injury Rate[3]	Restricted Activity Days[4]	Bed Disability Days[4]
1962-63	N.A.	N.A.	10.8	145.2	32.6
1963-64	N.A.	N.A.	12.3	174.2	40.9
1964-65	N.A.	N.A.	12.8	179.8	45.8
1965-66	N.A.	N.A.	12.8	211.5	51.2
1966-67	N.A.	N.A.	13.8	213.1	50.2
1967	N.A.	N.A.	12.2	190.5	45.1
1968	N.A.	N.A.	12.2	192.2	41.1
1969	N.A.	N.A.	10.7	157.9	31.1
1970	N.A.	N.A.	10.0	142.9	34.5
1971	N.A.	N.A.	12.4	155.5	38.9
1972	N.A.	N.A.	9.9	127.4	30.1
1973	11.0	10.6	10.8	149.4	38.6
1974	10.4	10.0	11.0	171.0	45.2
1975	9.1	8.8	11.8	166.8	43.6
1976	9.2	8.9	10.7	161.4	40.5
1977	9.3	9.0	12.6	176.7	41.1
1978	9.4	9.2	11.3	197.7	45.7
1979	9.5	9.2	12.4	182.5	42.1
1980	8.7	8.5	11.1	189.3	43.7
1981	8.5[5]	8.1[5]	11.3[6]	214.2[7]	43.8[8]

N.A. -- Not Available

1. Incidence rate per 100 full-time equivalent workers for all recordable injuries and illnesses in private sector employment.
2. Incidence rate per 100 full-time equivalent workers for only recordable injuries in private sector employment.
3. Number of medically attended or activity restricting injuries reported to the NIHS divided by the number of persons "currently employed" from the NHIS times 100.
4. Number of days per 100 "currently employed" persons.
5. Relative Standard error is less than 0.5%.
6. Relative Standard error is approximately 6.6%.
7. Relative Standard error is approximately 5.6%.
8. Relative Standard error is approximately 10.8%.

Source: BLS, Annual Survey and NCHS National Health Interview Survey.

Table 24

BLS Estimates of Recordable Occupational Illness, Private Sector, 1980

Illness Category	Number	Percent
TOTAL	130.2	100.0
Skin diseases and disorders	56.2	43.2
Dust diseases of the lungs	2.2	1.7
Respiratory conditions due to toxic agents	11.3	8.7
Poisoning	4.7	3.6
Disorders due to physical agents	13.2	10.1
Disorders associated with repeated trauma	23.2	17.8
All other	19.3	14.8

Source: BLS, Occupational Injuries and Illnesses in the U.S., 1980, Table 7.

Note: Because of rounding, components may not add to totals.

Table 25

Top 10 Occupational Safety and Health Problem Areas

#1 Occupational Lung Disease
- Lung cancer
- Silicosis
- Asbestosis
- Coalworkers' pneumoconiosis
- Byssinosis
- Occupational asthma

#2 Musculoskeletal Injuries
- Back/trunk disorders
- Upper extremity and neck disorders
- Lower extremity disorders
- Raynaud's phenomenon

#3 Occupational Cancers (Other than Lung)
- Bladder
- Leukemia
- Mesothelioma
- Nasal
- Liver

#4 Traumatic Deaths, Amputations, Fractures, and Eye Losses

#5 Cardiovascular Diseases
- Hypertension
- Coronary artery disease
- Acute myocardial infarction

#6 Reproductive Problems
- Spontaneous abortion
- Infertility, male
- Teratogenesis

#7 Neurotoxic Illness
- Peripheral neuropathy
- Toxic encephalitis
- Psychoses, extreme personality changes (exposure related)

#8 Noise Induced Hearing Loss

#9 Dermatologic Problems
- Dermatoses
- Burns, scaldings
- Chemical burns
- Contusions, abrasions
- Lacerations

#10 Psychological Disorders
- Neuroses
- Personality disorders
- Alcoholism
- Drug dependency

Source: NIOSH

Table 26

Blood-Lead levels of Exposed Workers
Before and After Promulgation of the OSHA Lead Standard[1]

Industry		Total # of lead exposed workers[3]	# of lead exposed workers in blood lead distribution	Estimated Percentages of Exposed Workers in Various Blood-Lead Ranges[2]			
				under 40	40-59	60-80	over 80
Primary lead smelting	1977	2,200		27.0	45.0	26.0	2.0
	1981-82		2,470	45.3	49.9	4.6	0.1
Secondary lead smelting	1977	3,170		29.0	30.0	25.0	16.0
	1981-82		1,524	40.7	51.4	7.0	0.6
Storage battery manufacture	1977	16,700		20.0	49.0	25.0	6.0
	1981-82		8,662	43.1	54.8	2.1	0

Source: Goble, Hattis, Ballew, et al., Implementation of the Occupational Lead Exposure Standard, CPA/83-20, Center for Policy Alternatives, M.I.T.: Cambridge, MA, November 1983.

1. Summarized from 43 Federal Register 54453-6, November 21, 1978, and Charles River Associates, Economic and Environmental Analysis of the Current OSHA Lead Standard (submitted to OSHA, 1982).

2. All blood-lead level are in micrograms per 100g.

3. Data on total number of exposed workers in 1977 from Ashford, N.A., Gecht, R.D., Hattis D.B., Katz J.I. The Effects of OSHA Medical Removal Protection on Labor Costs of Selected Lead Industries. CPA-77/11 December 1, 1977.

Table 27

Air Lead Exposures, Before and After Promulgation of the OSHA Lead Standard[1,2]

Industry		Total # of lead exposed workers	Number of contributing data to air lead distribution	Estimated Percentages of Exposed Workers in Various Air-Lead Ranges[3]		
				under 100	100-200	over 200
primary lead smelting	1977	2,200		18.0	21.0	61.0
	1981-82		2,790	35.6	19.5	44.9
secondary lead smelting	1977	3,170		21.0	12.0	67.0
	1981-82		1,799	37.3	22.6	39.9
storage battery manufacture	1977	16,700		57.0	23.0	21.0
	1981-82		8,936	81.4	13.2	5.4

Sources: Goble, Haddis, Ballew, et al., Implementation of the Occupational Lead Exposure Standard, CPA/83-20, Center for Policy Alternatives, M.I.T.: Cambridge, MA, November 1983.

1. Sources: based on information in Ashford, N.A., Gecht, R.D., Hattis, D.B. and Katz, J.I. The Effects of OSHA Medical Removal Protection on Labor Costs of Selected Lead Industries CPA-77/11 December 1, 1977 and Charles River Associates, Economic and Environmental Analysis of the Current OSHA Lead Standard (submitted to OSHA, 1982).

2. Under the pre-existing standard worker exposures were to be limited to an average of 200 ug/m^3 over an eight-hour day. (This standard was adopted at OSHA's inception in 1970 from prior voluntary industry consensus standards.)

3. All air-lead levels are in micrograms per cubic meter.

Figure 1

Disabling Injury Rate

Manufacturing, 1958–70

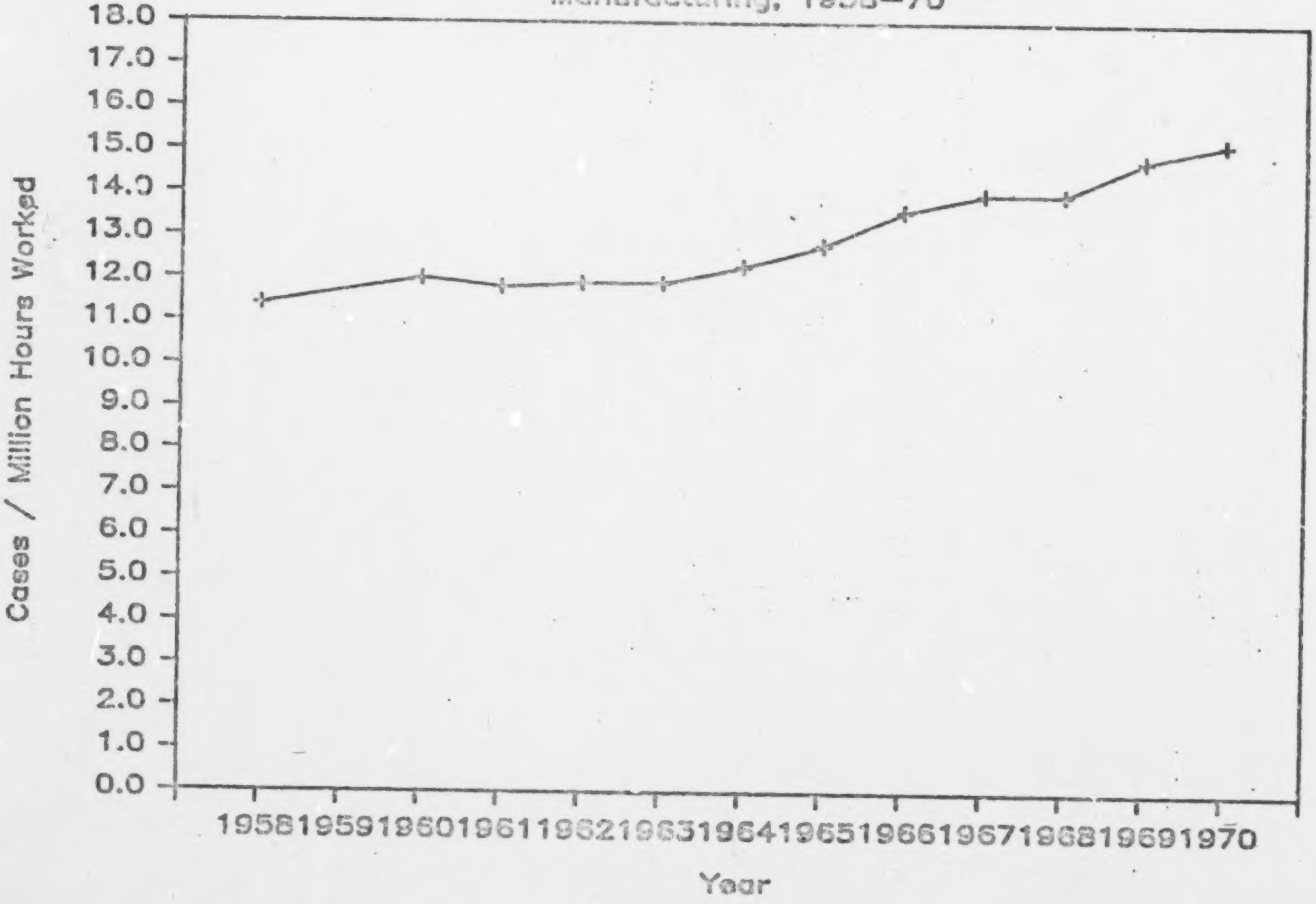


Figure 2

Occupational Injury Rates

Private Sector, 1972–83

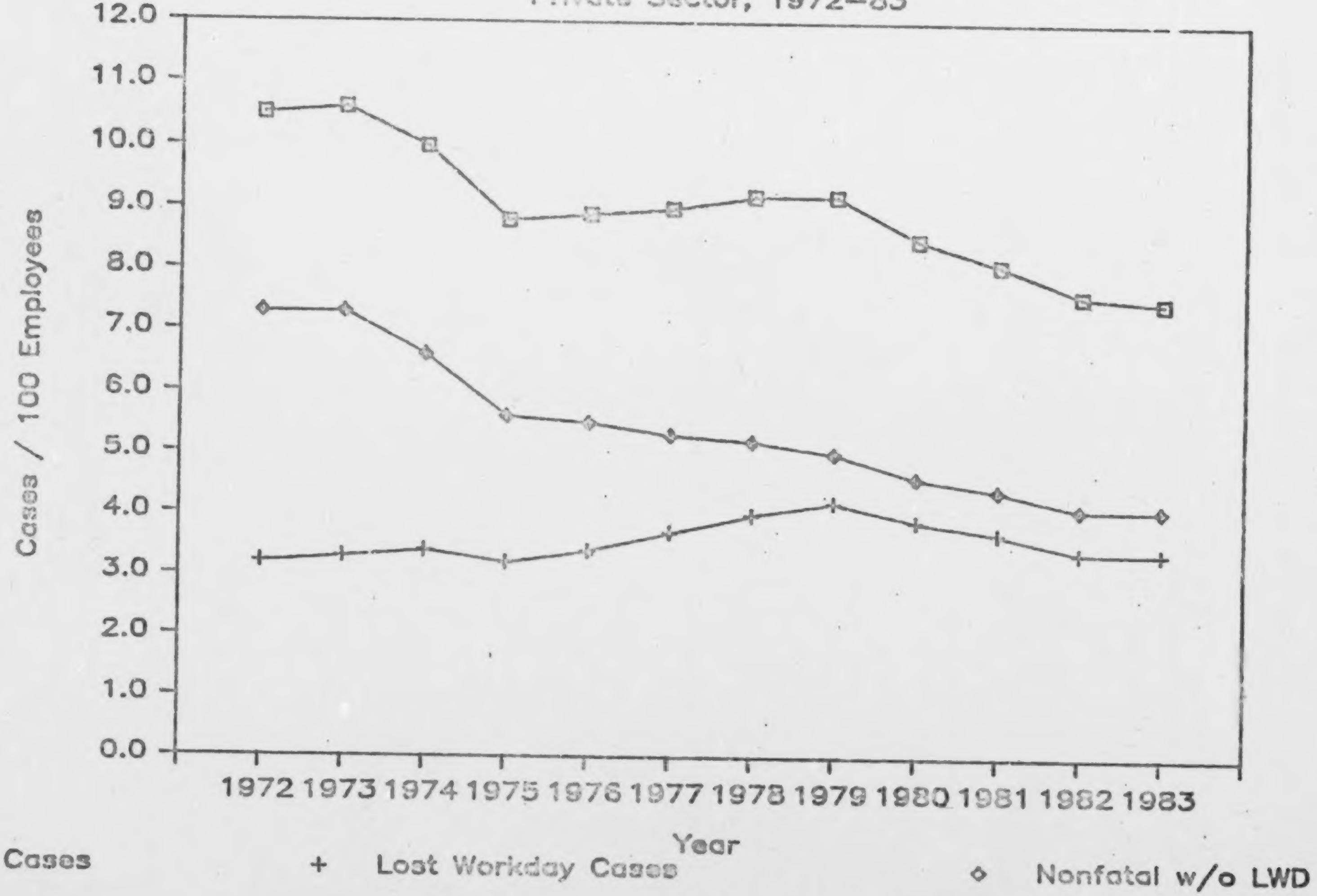
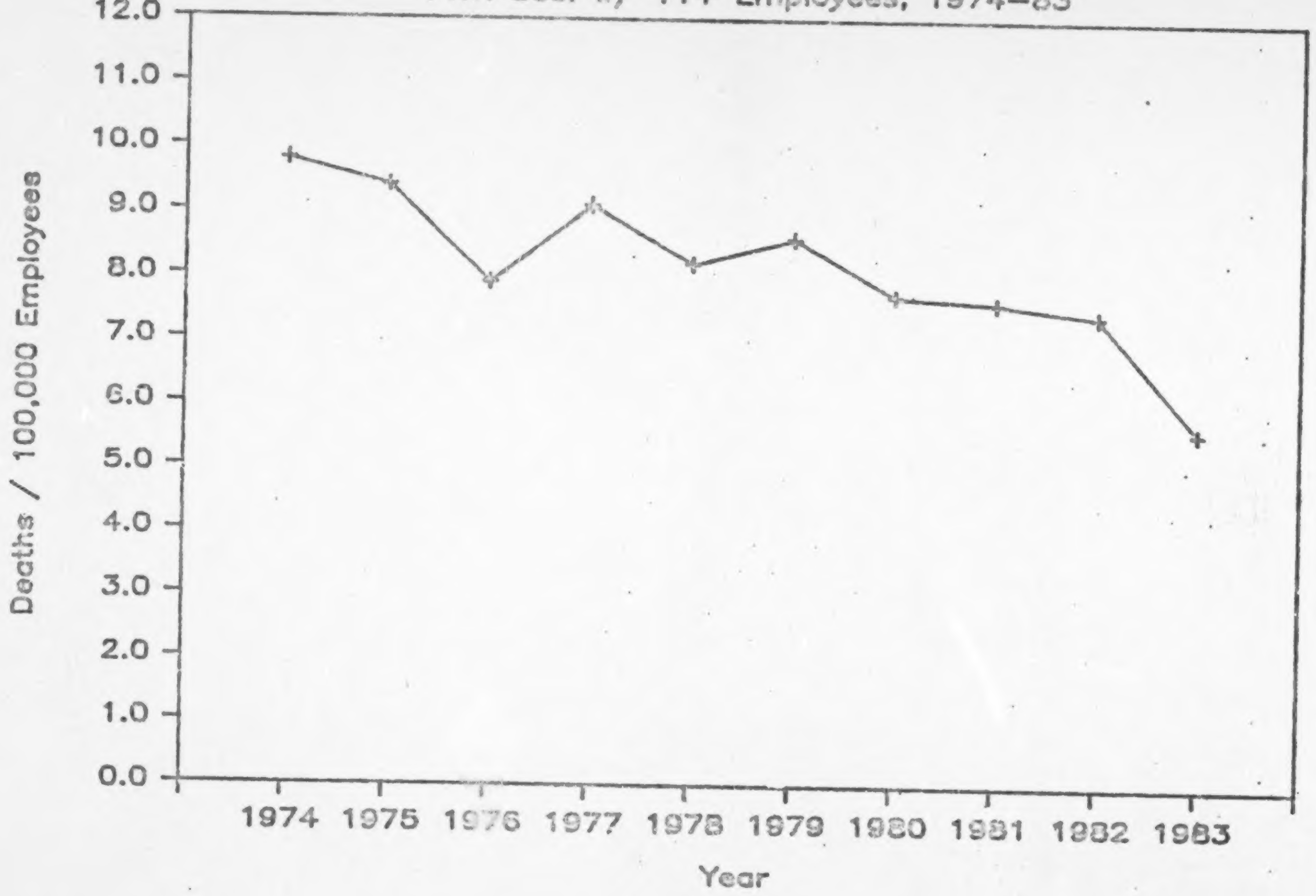


Figure 3



Occupational Fatality Rate

Priv. Sec. w/ 11+ Employees, 1974–83

Figure 4

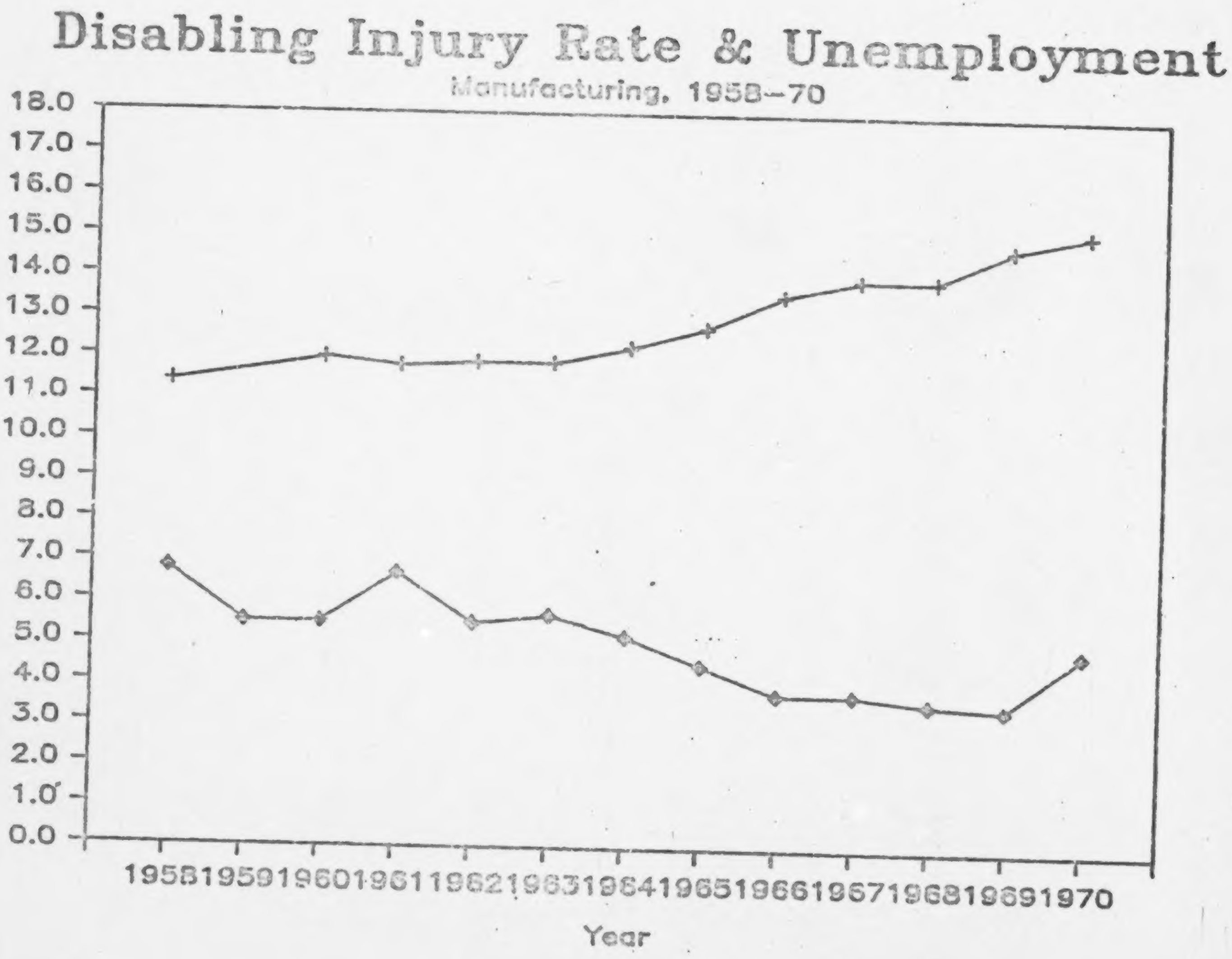

Disabling Injury Rate & Unemployment
Manufacturing, 1958–70
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Rate
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
Year

Figure 5

Disabling Injury Rate & Unemployment

Manufacturing, 1958–70

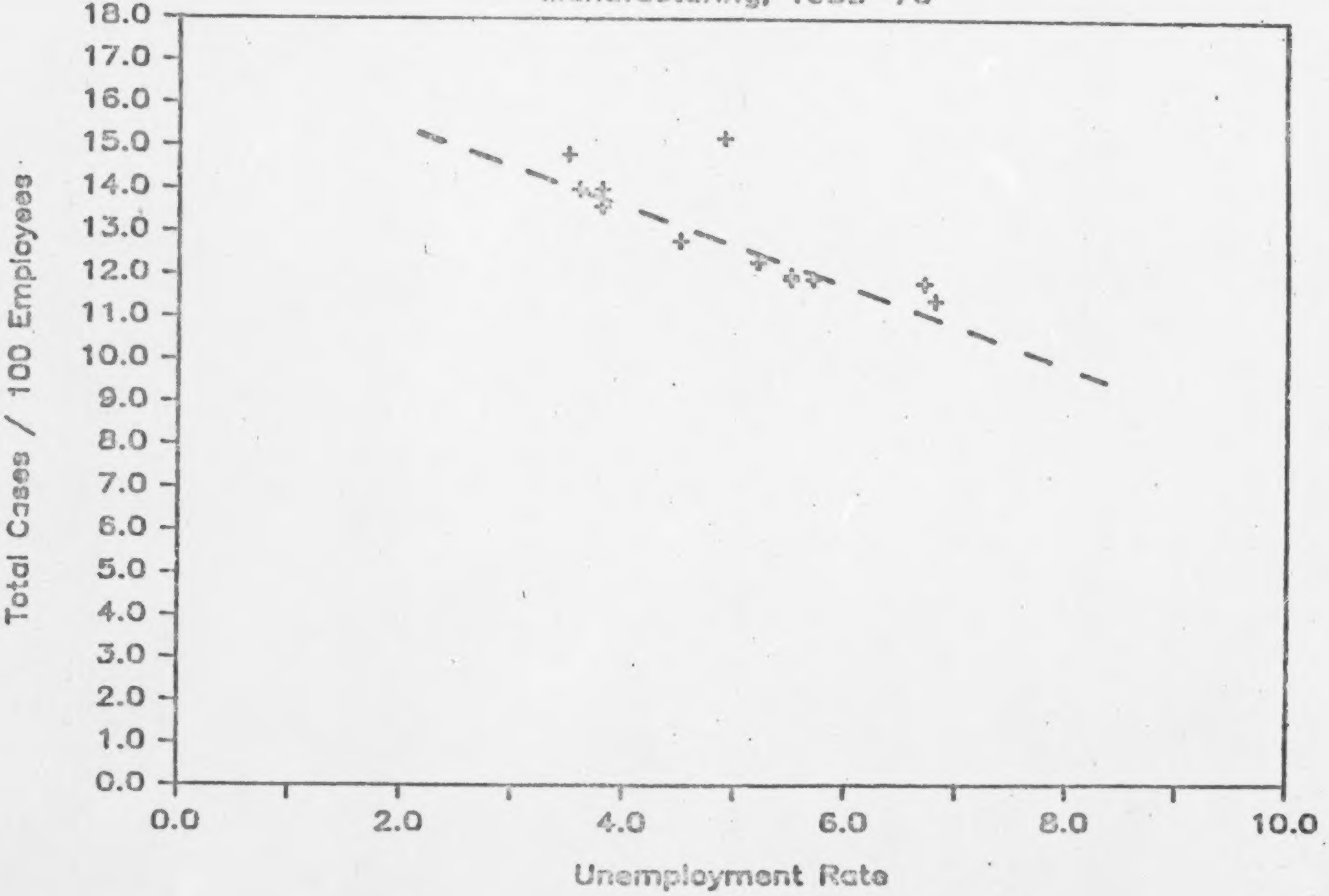


Figure 6

Total Injury Rate & Unemployment

Private Sector, 1972–83

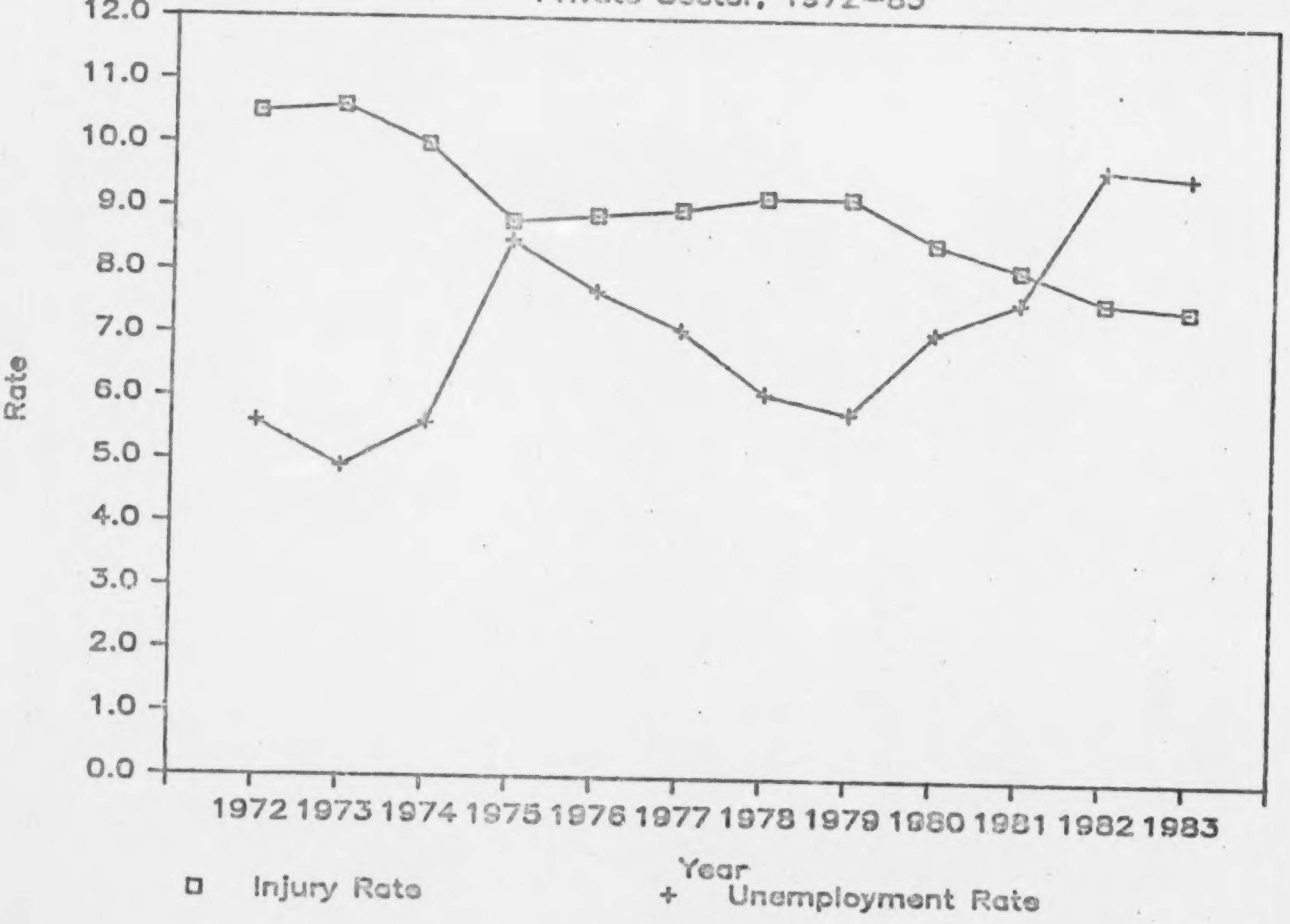


Figure 7

Total Injury Rate & Unemployment

Private Sector, 1972–83

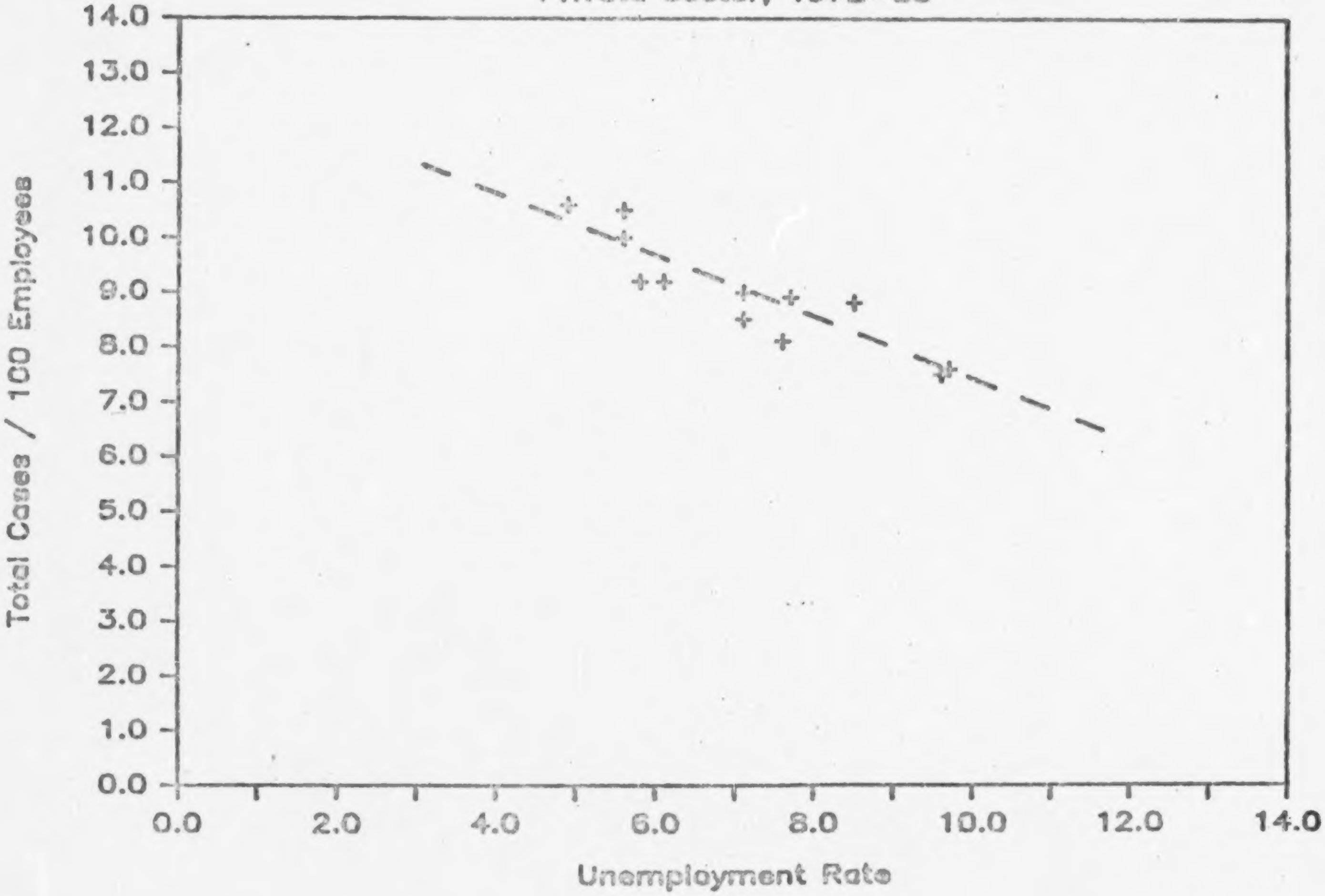


Figure 8

Lost Workday Rate & Unemployment

Private Sector, 1972–83

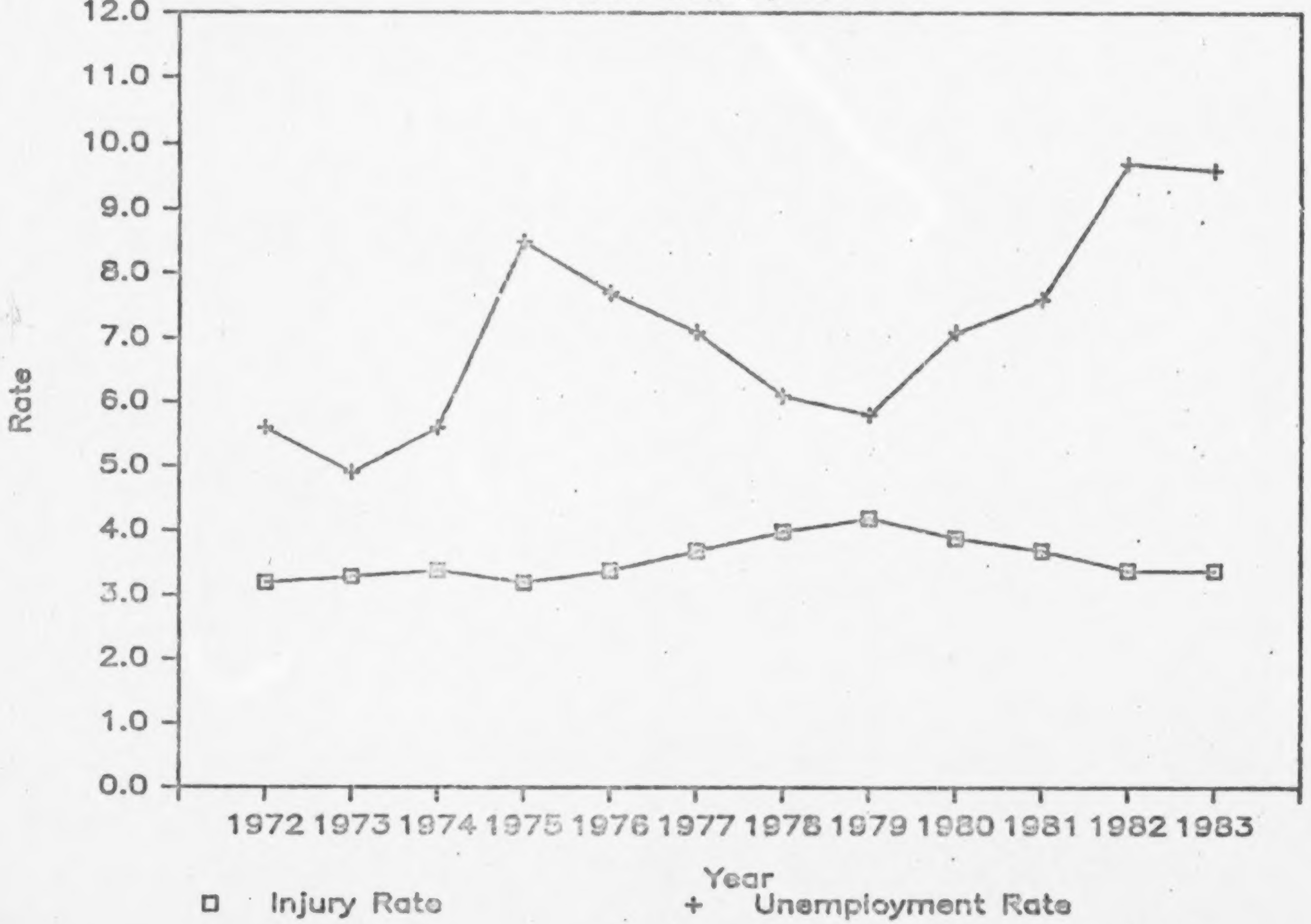


Figure 9

Lost Workday Rate & Unemployment

Private Sector, 1972–83

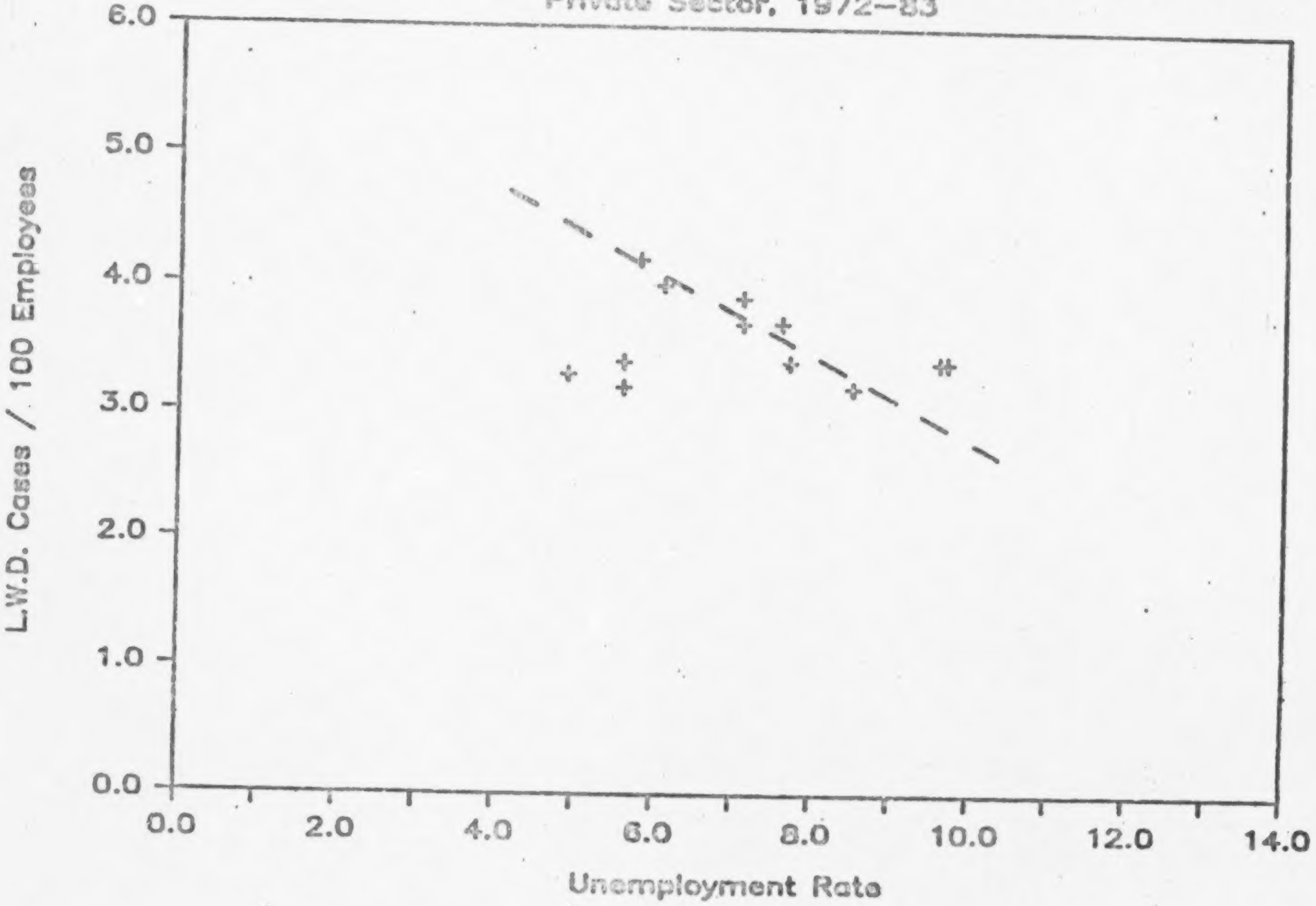
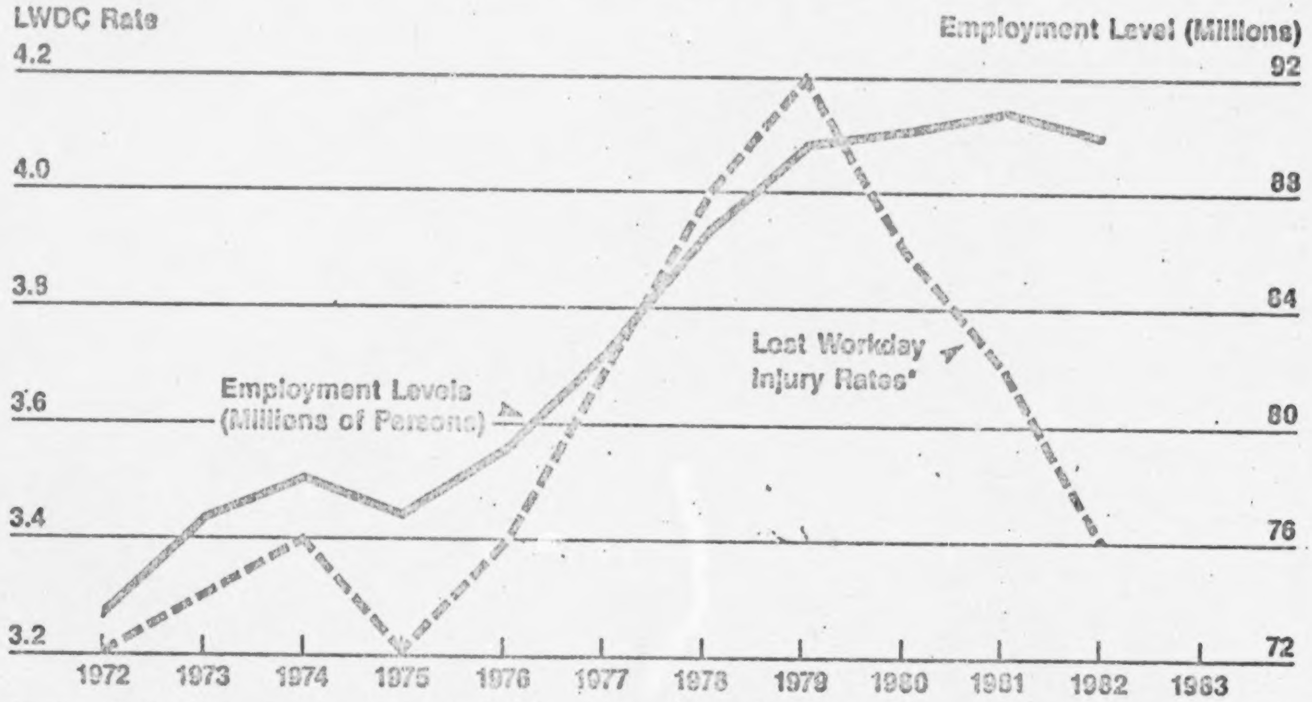


Figure 10

Lost Workday Injury Rates/ Employment Levels (CY 1972–1982)



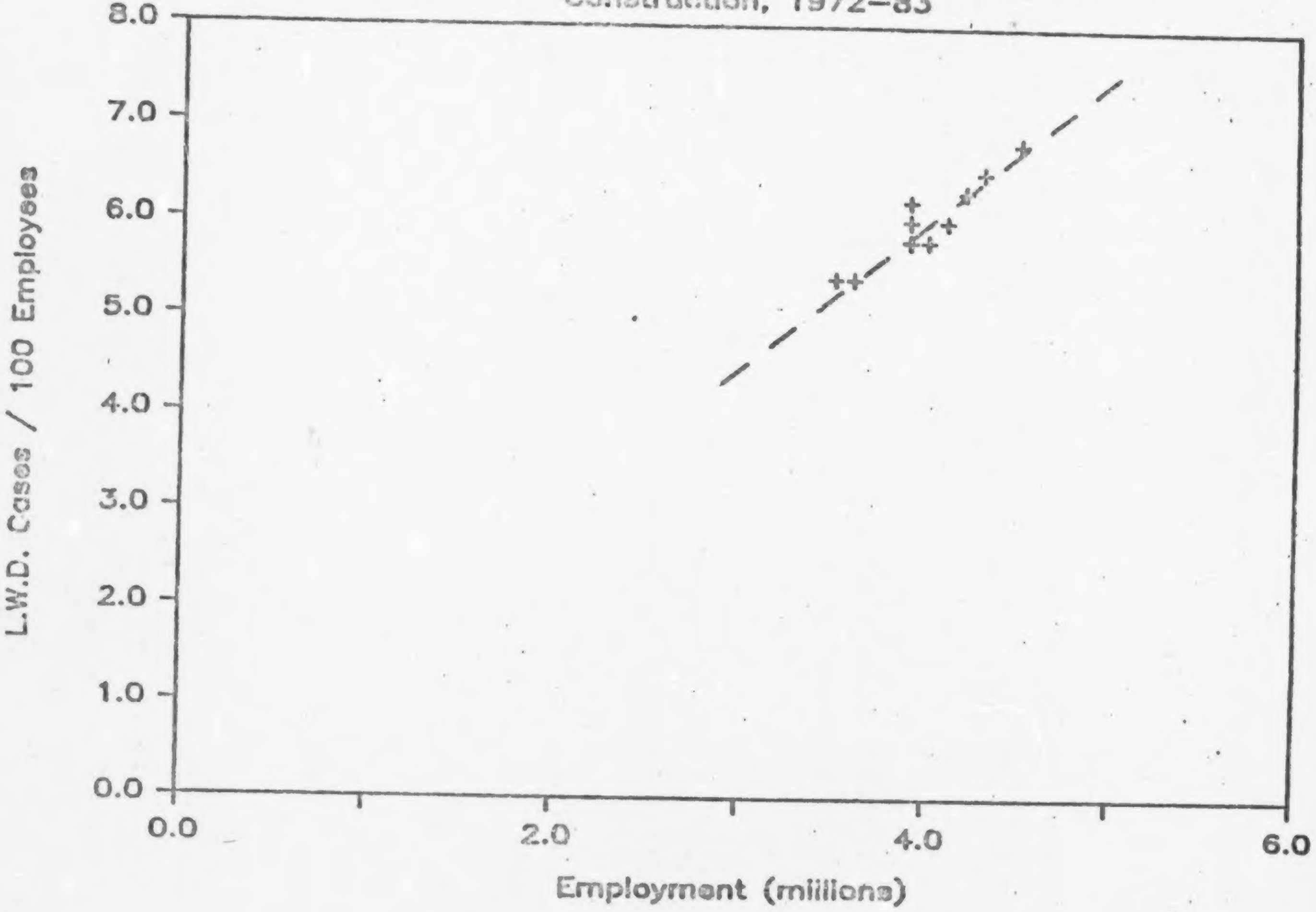
Source: United States Department of Labor, Bureau of Labor Statistics: "Occupational Injuries and Illnesses in 1982," and *Employment and Earnings*, March 1983, p. 65.

*Number of Lost Workday Injury Cases per 100 Full-Time Workers

11/83

Source: OSHA

Figure 11



Lost-Workday Rate & Employment

Construction, 1972-83

Figure 12

Lost-Workday Rate & Employment

Manufacturing, 1972–83

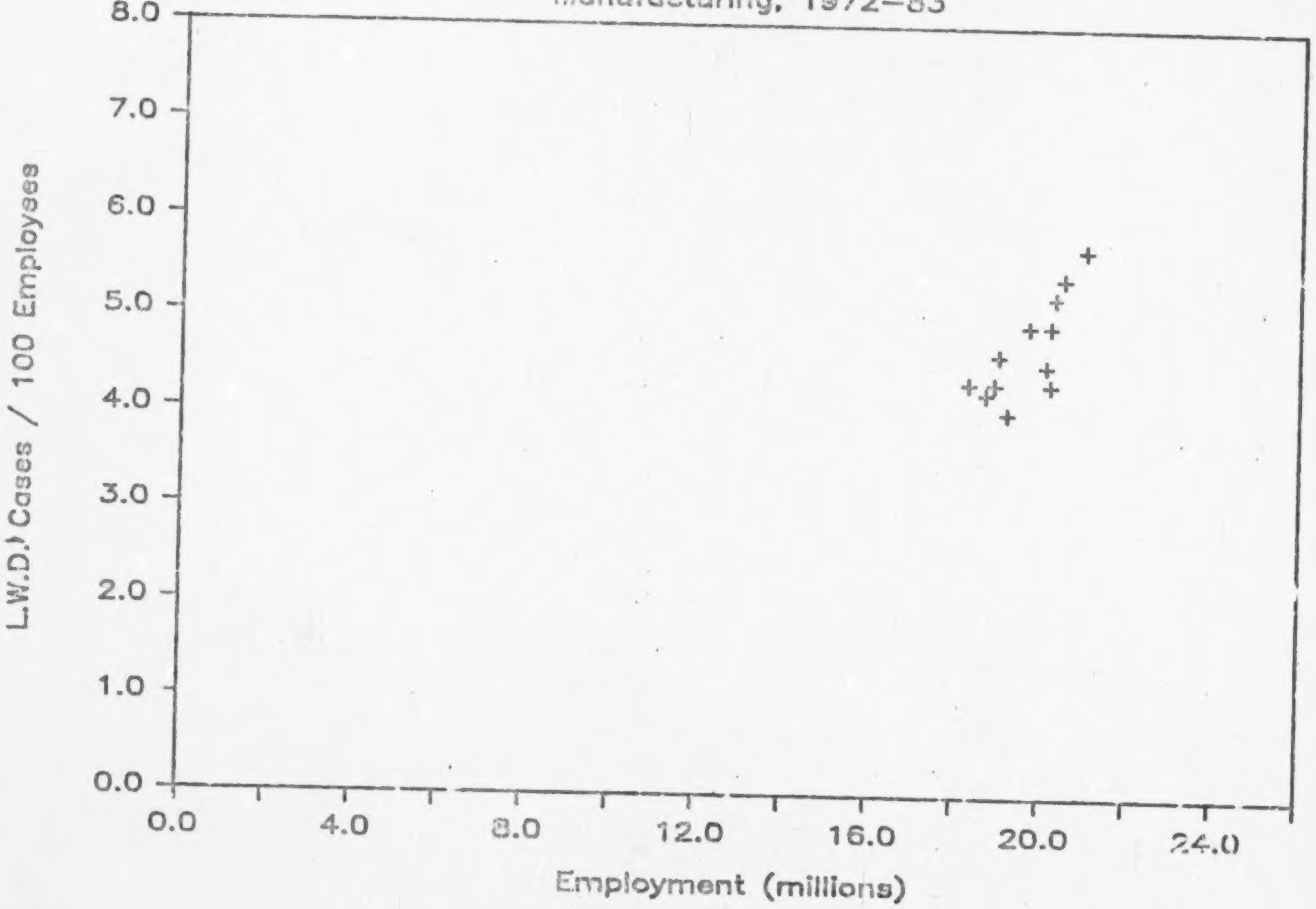


Figure 13

Lost-Workday Rate & Employment

Manufacturing, 1975–83

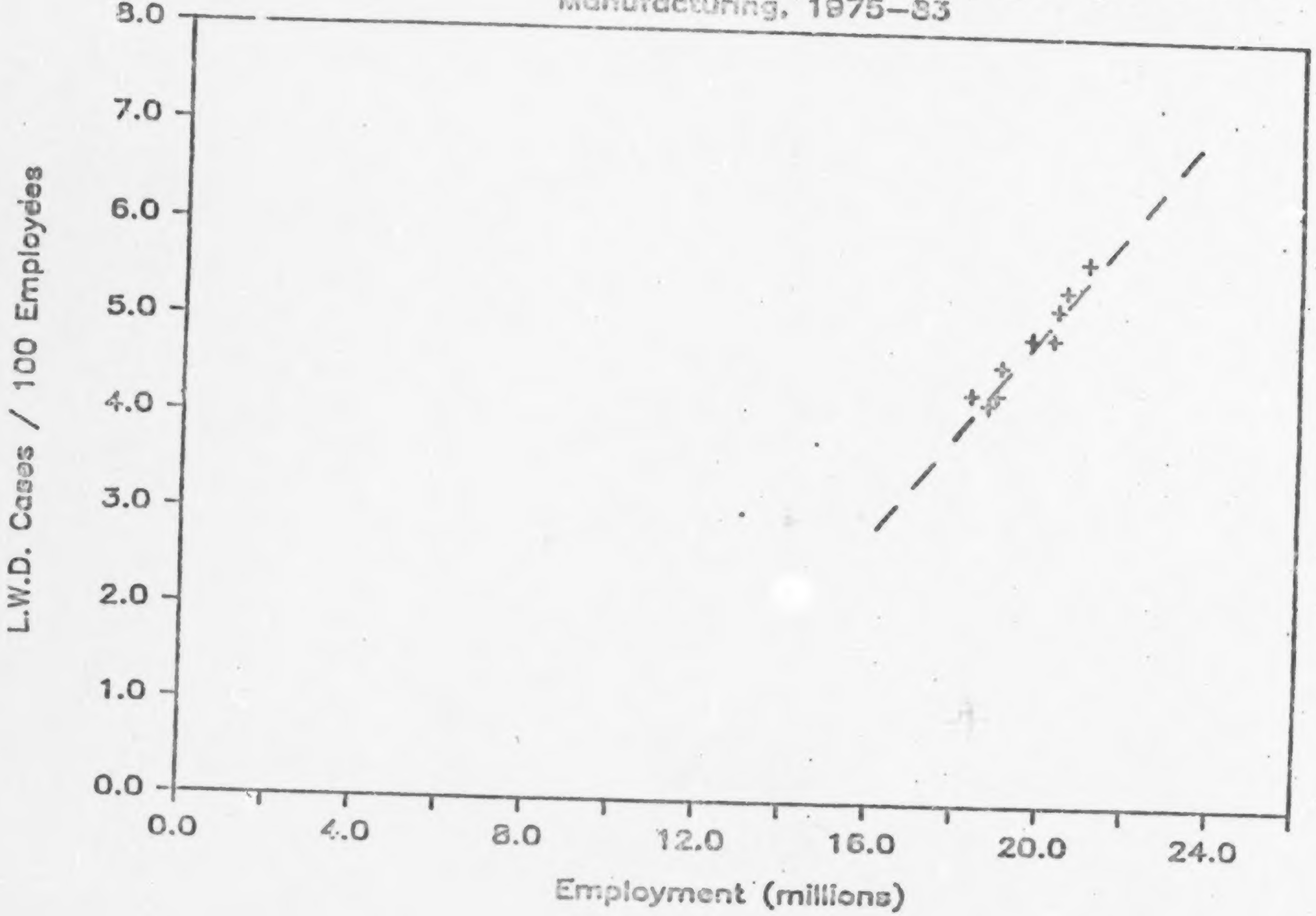
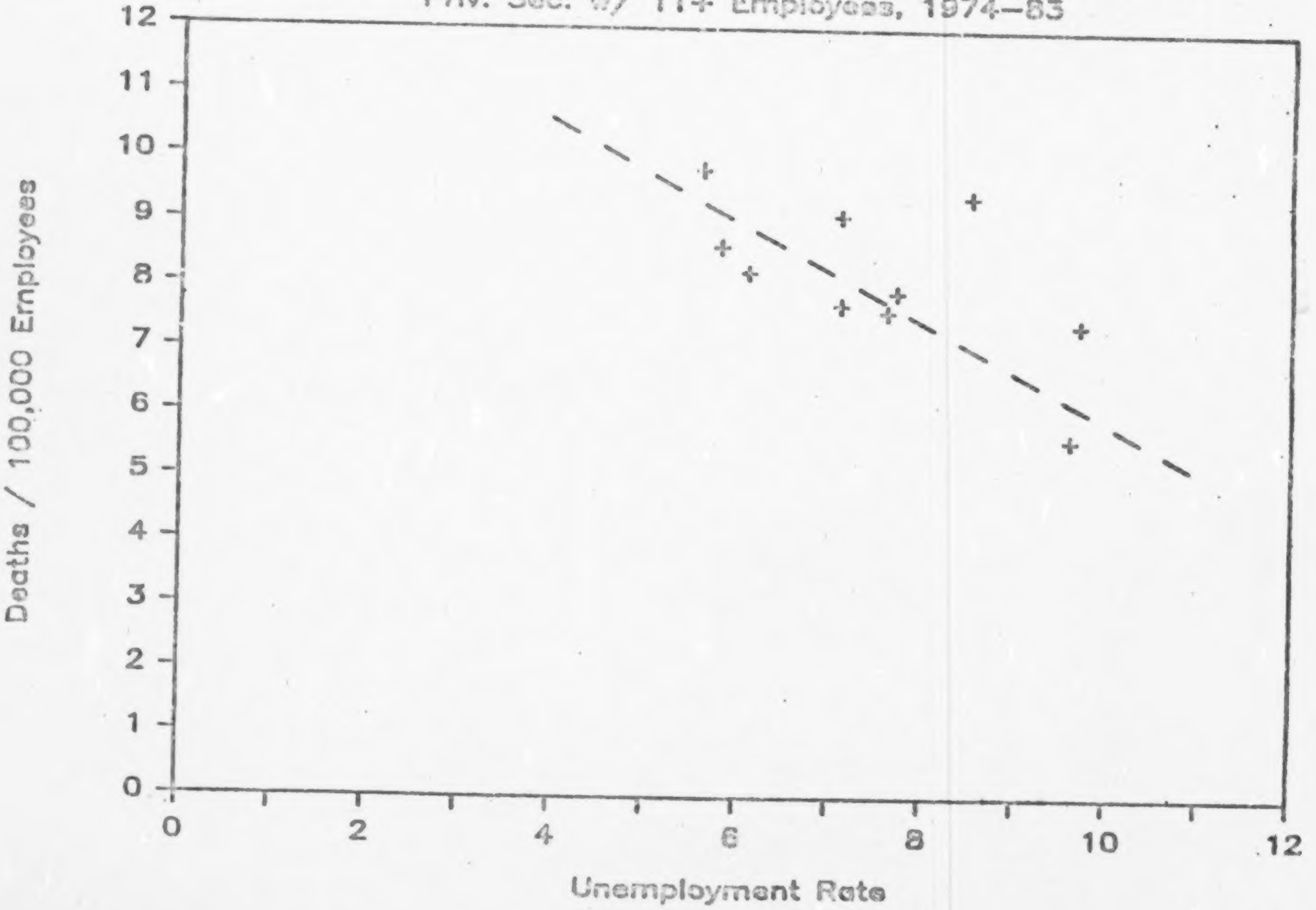


Figure 14

Fatality Rate & Unemployment

Priv. Sec. w/ 11+ Employees, 1974–83



An Analysis of OSHA Health Inspection Data

Prepared for the U.S. Congress, Office of Technology Assessment

by John Mendeloff

April, 1983

(The author gratefully acknowledges the helpful assistance provided by numerous OSHA staff.)

TABLE OF CONTENTS

EXPLAINING EXPOSURE LEVELS 1
- INDUSTRY AND TECHNOLOGY
- FIRM SIZE
- SIZE OF THE ESTABLISHMENT
- UNION PRESENCE
- PROFITABILITY
- LOCATION OF THE WORKPLACE
- MULTIPLE HEALTH HAZARDS
- AGE OF PLANT
- WORKER TENURE

EVALUATION 9

METHODOLOGICAL PROBLEMS

CHOOSING A DEPENDENT VARIABLE 11
THE OSHA INSPECTION SYSTEM 14
THE DATA IN THE OSHA MANAGEMENT INFORMATION SYSTEM (MIS) 17
DATA AND METHODS 22
DEFINITION OF THE VARIABLES 25

FINDINGS

INTRODUCTION 30
- UNION PRESENCE 32
- METROPOLITAN LOCATION 32
- NUMSUBS 34
- SEVSUBS 35
- ESTABLISHMENT SIZE 36
- INDUSTRY 41
- AGE OF PLANT 51
- INSPECTION TYPE 51

EVALUATION 51

USES OF THE OSHA MIS DATA

TARGETING INSPECTIONS 64
ASSESSING CURRENT EXPOSURES 66
EVALUATING EXPOSURE TRENDS AND OSHA'S IMPACT 69

TABLES AND FIGURES

TABLE 1 OSHA INSPECTIONS BY TYPE AND FISCAL YEAR

TABLE 2 NUMBER OF INSPECTIONS BY INSPECTION TYPE: SELECTED SUBSTANCES BY YEAR

TABLE 3 PERCENTAGE OF INSPECTIONS WITH VIOLATIONS FOR OVEREXPOSURES BY INSPECTION TYPE: SELECTED SUBSTANCES

TABLE 4 PERCENTAGE OF INSPECTIONS FINDING OVEREXPOSED WORKERS BY YEAR AND THE PERCENTAGE OF THOSE INSPECTIONS WHICH LED TO CITATIONS FOR OVEREXPOSURES

TABLE 5 CHANGES IN THE SUBMISSION OF HEALTH TEST SAMPLES TO THE OSHA MIS OVER TIME: THERE WAS LESS COMPLETE REPORTING IN RECENT YEARS

TABLE 6 PROPORTION OF INSPECTIONS WITH SAMPLING FOR OTHER TOXIC SUBTANCES

TABLE 7 SHORT DESCRIPTIONS OF THE VARIABLES

TABLE 8 MEAN VALUES OF THE DEPENDENT VARIABLES

TABLE 9 REGRESSION SUMMARY STATISTICS

TABLE 10 RESULTS: REGRESSION ON "OVEREX" FOR ALL ASBESTOS INSPECTIONS

TABLE 11 TESTEMP (NUMBER OF EMPLOYEES TESTED) BY SIZE CLASS OF WORKPLACE

TABLE 12 DIFFERENCES AMONG INDUSTRIES IN THE WEIGHTED SEVERITY OF EXPOSURES (WSEVPER): ALL INSPECTIONS

TABLE 13 REGRESSION ON "OVEREX" FOR LEAD GENERAL SCHEDULE INSPECTIONS

TABLE 14 REGRESSION ON "OVEREX" FOR LEAD COMPLAINT INSPECTIONS

TABLE 15 AVERAGE INDUSTRY COMPLIANCE COSTS PER "EXPOSED WORKER" AND THE EFFECT OF INDUSTRY ON THE PROPORTION OF INSPECTIONS FINDING OVEREXPOSURES

TABLE 16 COMPLIANCE COSTS FOR SELECTED INSPECTIONS

TABLE 17 HAVE EXPOSURES DECLINED OVER TIME? THE COEFFICIENTS FOR "YEARS" ON THE GENERAL SCHEDULE REGRESSIONS

TABLE 18 HAVE EXPOSURED DECLINED OVER TIME? COMPLAINT INSPECTIONS

TABLE 19 DO EXPOSURES DECLINE WHEN RECOMMENDED EXPOSURE LIMITS ARE REDUCED?

TABLE 20 CHANGES IN EXPOSURES AFTER NEW OSHA STANDARDS: ASBESTOS AND VINYL CHLORIDE

TABLE 21 A COMPARISION OF THE NUMBER OF INSPECTIONS FOR LEAD IN CERTAIN INDUSTRIES WITH THE NUMBER OF PLANTS IN THOSE INDUSTRIES ACCORDING TO THE 1977 CENSUS OF MANUFACTURERS

FIGURE 1 THE EFFECTS OF ESTABLISHMENT SIZE ON OVEREXPOSURES: GS INSPECTIONS

Executive Summary

This report uses inspection results from the OSHA Management Information System (MIS) to address two questions: 1) What characteristics of establishments influence how well they control toxic exposures; 2) Is there any evidence that exposures have declined over time or that OSHA can claim credit for those reductions?

A series of methodological obstacles make it difficult to make unambiguous inferences from the findings of this study. The chief problems are first, that workplaces are not inspected in a random process and thus that the results for inspected workplaces might not apply to uninspected workplaces, and second, that in about 50% of the inspections, the exposure sampling results were not submitted to the MIS. These problems pose the greatest problems for the evaluation effort. Yet, the main findings here should be of interest, even pending further examination of their validity.

Inspection findings from 1972 to 1979 for four toxic substances - asbestos, lead, silica, and trichloroethylene - were examined in separate multiple regressions. Five difference measures of exposures or compliance were used: whether any exposure above the PEL was found (OVEREX), whether any citation was issued (ANYCIT), the number of workers exposed above the PEL (SEVEMP), the percentage of workers sampled whose exposures were above the PEL (SEVEMP), the percentage of workers sampled whose exposures were above the PEL (SEVPER), and a weighted measure of the severity of the exposures for the workers sampled (WSEVPER).

The independent variables explained between 5% and 25% of the variation in these exposure findings. Contrary to expectations, presence of a union did not lead to reductions in exposures. Location in a non-metropolitan area did, however, usually increase exposures. Workplaces with fewer than 20 workers or more than 1000 had fewer overexposures than middle-sized plants. The finding for small plants was a surprise; however, different measures of performance might reveal a clearer negative relation between size and overexposures.

Workplaces with greater numbers of toxic substances - as measured by the number of toxic substances for which OSHA sampled - did a better job of controlling them. However, overexposures to one toxic substance did make it more likely that there would be overexposures to others as well. Complaint inspections were neither more or less likely to find overexposures than general schedule inspections, although follow-up inspections, on average, found lower exposures.

Differences in overexposures among industries were often quite large, although few industries had consistently high or low exposures across all four substances. That result is not surprising if the variations are due to differences in processes that are specific to each substance. Evidence for lead exposures supports the hypothesis that the extent of compliance depends largely on the per worker cost of compliance in the industry.

For asbestos, overexposures appear to have decreased considerably over time. For silica and trichlorethylene, there is some evidence of declining exposures, although it is less strong. For lead, there are no signs of improvement. Even for the substances for which exposures had declined, the likelihood of health citations went up, apparently because of a heretofore unknown change in citation policy after 1974. Consequently, use of the ANYCIT measure will mask improvements that may have occurred since 1973. The biggest decline in exposures occurred in

1977, the year after the highest citation rate. This raises the question of a causal connection between the two.

Finally, using the broader MIS data set, we compared two groups of toxic substances: one for which new recommendations for lower exposures had appeared and one for which recommended exposures limits had not changed. The changes in exposures for the two groups were not statistically distinguishable, suggesting that, by itself, new information about hazards has not been sufficient to induce additional abatement efforts.

Exposure data in the MIS appears to have two promising uses. The first is to assist OSHA in targeting health inspections on the types of workplaces where past inspections have found problems. The second is to provide rough indicators of the magnitude of current exposures, estimates which could be used to supplement the National Occupational Health Survey in establishing priorities for standard-setting.

Explaining Exposure Levels

How can we explain why toxic exposures are poorly controlled at some workplaces and well controlled at others? This research will try to supply at least a partial answer. We will be using the findings of OSHA's health inspections and the characteristics of the inspected firms as the basic data to test hypotheses. One useful outcome of the research should be insight about OSHA's effectiveness in reducing exposures and about where health inspections should be targeted to be more fruitful. After laying out a framework for analyzing firm behavior,we will review the specific hypotheses that we can generate. Although the data to test some of the hypotheses are not available, the final section includes tests of most of them.

The search for explanations of firms' behavior in controlling exposures must begin with a more general model of firm behavior. In the simplest formulation, the firm's behavior depends upon knowledge and incentives. Do firms know whether a problem exists and, if so, do they know what can be done about it? Given this knowledge, do they have any incentive to act on it? Complications arise immediately: whether firms have knowledge depends in part upon whether they have any incentive to gain knowledge; the incentives perceived by the firm are also, of course, partly a function of their understanding of the consequences of actions and inaction. Furthermore, we need to focus on the knowledge and incentives possessed by those who are actually making the decisions, which may differ depending upon where they sit within the firm.

If profit maximization is the firm's objective, then measures to protect workers from occupational disease threats will be undertaken as long as the present value of the expected marginal benefits to the firm exceed the present value of the expected marginal costs to the firm. The costs will depend upon the labor and capital needed to install and maintain controls as well as upon any negative impact on the production process itself. The factors that affect the marginal costs of control would appear to include:

1) Knowledge about the hazard.

2) Knowledge about control technology.

3) Characteristics of the technology.

Possession of knowledge reduces the costs that firms would have to incur to figure out whether they had a problem and what they could do about it. It is difficult to generalize about characteristics of technology, but a few predictions seem plausible. Controls that require replacing equipment will be less costly when the existing equipment is about to be replaced anyway. High rates of technological change will be a spur to capital investment. However, when controls involve retrofitting, it is likely that the costs will be higher for older equipment than for newer equipment for the same reason that older plumbing is harder to fix than new plumbing.

The marginal benefits in this model will depend upon some amalgam of the reduced costs to the firm due to reduced disease and the reduced cost due to workers' subjective valuations of the controls. These correspond to the ex post compensation of workers' compensation and the ex ante compensation of wage premiums. (In the case of occupational disease, we know that ex post compensation is unusual and the payments are small. Ex ante compensation can be expected only if workers are aware of the hazard.) Improved productivity is another possible benefit. Affecting the health benefits are the number of workers protected by a given control, the severity of the hazard, the acuteness of the effect, and the degree of worker knowledge and concern. From the firm's perspective, if workers are uninformed or unconcerned, controls may not have any benefits except for the reduction in _ex post_ compensation. The ex post compensation will be affected by the extent of the employer's self insurance.

In addition, the marginal benefits are likely to be greater when the firm contemplates maintaining the facility for a long period. Also, if workers are exposed to several possible hazards, the controls may have broader benefits.

A less restrictive model of firm behavior would also allow us to consider factors like the benefits to company industrial hygienists from maintaining professional standards or the gratification of managers in feeling that they are being properly protective. (The other side of that coin, though, may be denial that there could be any problems.)

In the following discussion, we try to identify the variables that an empirical investigation of inter-firm variability should focus on.

Industry and Technology

Obviously, the likelihood of dangerous exposures to a particular toxic substance varies greatly depending upon the technological processes that are involved. Interviews with OSHA hygienists indicate, for example, that soldering rarely is associated with excessive lead exposures, while battery manufacturing often is. Even without industrial hygiene controls like local exhaust ventilation, a soldering operation is unlikely to generate exposures above the permissible exposure level (PEL). The only method we have for trying to identify technological differences is to use the industry categories of the

Standard Industrial Classification (SIC). The SIC categories enable us to distinguish battery manufacturing from an electronics firm which makes heavy use of soldering. But there are often more subtle differences which the SIC measure will not capture. Firms in the same SIC producing the exact same product may use different processes. Firms in the same SIC--even at the 4 digit level of detail--can produce very different products which involve different processes. For example, both asbestos friction products and asbestos flooring are in SIC 3292. Differences in the amount of lead in the paint used in spray painting or in the amount of lead in the solder--both of which may be related to the requirements of the product being manufactured--will affect the nature of the hazard created and the difficulty of controlling it.

By determining whether any control technology is needed and, if so, what kind, these technological factors obviously influence the costs of control. If we had establishment-specific data on the cost of reducing exposures at particular operations, this would be the ideal explanatory variable in terms of the model of firm decisionmaking that is outlined above.

Firm Size

We should expect larger firms to have lower exposures for several reasons. First, for acute hazards they will probably bear all of the compensation costs due to self-insurance, while experience rating for smaller firms protects them from bearing the full costs they impose. Second, although all firms may discount chronic hazards into insignificance; if they don't, then large firms are more likely to care about them because they are far more likely than small firms to exist 20 years later. Uncertainty about existence increases the small firm's discount rate. Third, and probably most important, large firms have more in-house expertise. This point, not surprisingly, is often stressed by industrial hygienists. The differences reported in the NIOSH National Occupational Hazard Survey (NOHS) are striking. For manufacturing, industrial hygiene services were used in 12.4% of all plants but in 70.0% of plants with over 500 employees. Environmental conditions are regularly monitored in 6.1% of all plants and 51.1% of the larger plants. (Federal Register, May 23, 1980, p. 35255.)

Large firms are also more likely to be sensitive about their reputations. Episodes like the kepone fiasco besmirch the corporate image. To control these intra-firm externalities, firms are likely to restrict local decision making and demand adherence to corporate standards. It is common to hear local officials explain that it is corporate policy to comply with federal laws. While corporate policy may not always seek compliance and may not always be obeyed when it does, firms may prefer corporate-wide standards over the possibly more efficient, but alsomore data demanding, alternative of plant by plant balancing of costs and benefits.

In possible disagreement with this line of reasoning, Viscusi observes (based on data from The Michigan Survey of Working Conditions) that the coefficient on workplace size is positive and significant in a regression explaining whether workers perceive their job as presenting health dangers. He argues that the reason is that the productivity loss due to injured workers is smaller at larger firms and thus that these enterprises will select higher levels of risk. For safety, where no effect was found, this impact may be offset by the merit rating effect of workers' compensation. (p.269)

Size of the Establishment

The larger an individual workplace, the better controlled exposures are likely to be. While large plants are obviously more likely to be part of large firms, this relationship is posited to be independent. First, even within large firms, expertise is most likely to be easily at hand at the larger plants. Second, a large plant is more likely than a small one to develop a reputation in a local labor market. If reports that a plant is dirty or dangerous are circulated, achievement of its hiring objectives may be hindered. Third, larger plants--as explained below-- face higher threats of inspection and all firms that are inspected and cited face considerable pressures to comply.

Union Presence

The presence of a union is expected to reduce exposures. Unions have several effects. First, they are likely to make workers better informed about health hazards. Second, they can protect workers who complain about health hazards. Third, they can increase workers' bargaining power with management, although a long debate has raged about the extent of this impact. Viscusi notes that The Michigan Survey of Working Conditions shows that workers in unions are more likely to report facing safety hazards but less likely to report facing health hazards and he tentatively concludes that "Overall unions appear to accept greater safety risks in return for higher levels of compensation. For health risks, the emphasis appears to be on reducing the hazard." (p.270)

Of course, unions vary greatly in their competence and concern with occupational health problems and in their bargaining power. Union power depends not only on the extent of the industry organized and the bargaining structure, but also on the elasticity of demand for American labor and for the product.

Profitability

Many writers have suggested that firms with good safety programs are firms that generally do most things well. Although trade-offs must still exist among different objectives, "good management" shifts the production frontier out so that the firm can get moreof several good things (profits, safety, etc.) than a poorly managed firm could get. Given this perspective, if injury rates reflect management quality, then so should toxic exposures. But it is possible that lower accident rates generally increase profits while lower exposures do not. Information to calculate the likely effects of a particular project on profits is, however, rarely available. Even without any data, many employers may feel that they know that certain compliance measures have high costs and no benefits. However, in the design of new production processes or products, managers rarely have data that allows credible predictions. Instead, reliance is placed on industry standards, "the state of the art," and the judgment of professionals, although these may sometimes be breached or ignored.

To the extent that good management contributes to a firm's profitability, we may find profitability and low exposures go together. A contrasting view is that low exposures are a frill which only profitable firms can afford. Thus a finding that low exposures were correlated with profitability would not enable us to distinguish which view was correct. Of course profitability is also determined by industry structure. Firms that had high profits compared to most firms (an industry effect), but low profits compared to most firms in its industry (a management effect) might provide a test case of the "frills" versus "good management" explanations. (One problem is that the only firms for which profit data are available are large ones, which invariably have many plants and usually operate in several product markets.)

Location of the Workplace

Establishments in non-metropolitan locations may have poorer access to information, at least if they are not part of larger firms. Also, in such locations, the job alternatives are likely to be more restricted (especially if that plant is a large one) and thus labor market pressures on employers may be weaker.

Multiple Health Hazards

Firms with multiple health hazards may have lower exposures than those with only one, especially if the hazards arise in similar parts of the workplace and can be addressed by similar controls. The marginal costs of getting information are likely to be smaller as the number of hazards increases. More important, if the same ventilation or monitoring system can address both, the benefits of the controls will be greater than if they addressed only one.

Age of Plant

Firms with newer plants are likely to have lower exposures because it is presumed to be cheaper to install controls at the design phase and the trend over time has been to lower exposures. That such a trend exists has not been rigorously established, but most epidemiological studies which have evidence of exposures 20 to 40 years ago indicate that they were substantially higher in the past.

Worker Tenure

Firms with workers with higher average tenures may be more likely to have higher exposures because those workers have more to lose in terms of the benefits of seniority if they leave. They may also feel that they've been exposed so long that further exposures can't do much harm. The assumption here is that the firm is more responsive to "exit" than it is to "voice" or that the workers will not try to use voice. At non-union plants, the latter is plausible. However, long tenure workers will tend to be older and more likely to fall victim to occupational disease. If the firm thinks that reducing exposures will reduce near-term occupational disease compensation costs, preventive measures may be forthcoming. Predictions on these points don't have a very solid base.

Evaluation

Occupational diseases reporting is notoriously inadequate. Even if it were not, the long latency periods for many diseases creates a need for measures of how well we are currently doing in preventing future diseases. For these reasons, it would be very valuable if we could use MIS data as a tool for evaluating whether, over time, the workplaces OSHA has inspected show a declining frequency of overexposures; but because workplaces are not inspected randomly, we can't confidently assume that the results apply to all workplaces. a problem will arise if the likelihood of inspecting workplaces with overexposures changes over time due to some factor that is not reflected in the variables in the equation - e.g. industry, size, etc. For example, suppose that inspectors often knew which plants had serious problems because they had access to pre-OSHA state inspection results. In that case, early inspections might have focused on plants with high exposures, creating the false impression that conditions have improved. Alternatively, if inspectors learn over time that particular firms or particular processes are likely to involve overexposures, their targeting may improve and a false impression of deterioration may be created. If workers become more discriminating in their requests for inspections, then a higher rate of violations would also become more likely.

The actual processes which generate health inspections are described more fully below. Overall, it is simply not clear whether we should expect such unmeasured biases to be insignificant. Therefore, the findings should be interpreted with some caution.

A second issue is OSHA's impact on worker exposures. This impact may occur in the absence of an inspection (i.e., because the firm is law-abiding) or in its aftermath. We should expect that once a firm has been cited for an overexposure, it will take steps to abate it. Thus subsequent inspections should find a decrease in exposures. Although the high exosures at these plants should go down, it seems unlikely that we should expect the resulting exposures to be lower than those found in first time inspections at other plants. When a plant is inspected and the air sampling finds no overexposures of the substance in question or if no air sampling is conducted, we still might expect the inspection to sensitize the firm to OSHA's requirements.

Aggregated annual data on each toxic substance can also be used to examine some interesting issues about the impact of information and professional norms in the absence of regulation. Some have suggested that some or all of the reductions in exposures that have occurred following new OSHA standards would have occurred anyway as a result of the new information which often helped to trigger standard-setting proceedings. (Several qualifications are needed here: reduced exposures have not been well-documented and the role of information - much less new information - in triggering the proceedings is often hard to find.)

One way to test the "information hypothesis" is to examine what has happened to exposures for those substances for which new information has become available even though no prospect of regulation was imminent. Examples include reductions in threshold limit values by the private ACGIH, criteria documents from NIOSH that recommend lowered exposures, and perhaps current Intelligence Bulletins that warn of new toxic effects. What has happened to exposures to these substances compared to those which OSHA has adopted new regulations for or compared to substances which have been the subject of no new action of any kind?

Methodological Problems

Choosing a Dependent Variable

How should we assess how well employers are doing in controlling toxic exposures? It is not apparent to me that any one of the possible dependent variables is obviously superior on all counts. One issue is whether we want to use a measure of the absolute number of workers exposed or a standard that measures the level of exposure only among those exposed. A larger plant might have50 workersexposedto lead compared to 10 at a small firm. If 5 workers are exposed above the PEL at a large plant and 2 at the small plant, which is doing the better job of controlling exposures? What we are really trying to measure is success in protecting workers. Although both measures should be looked at, my preference is to emphasize the percentage of exposures which are excessive instead of the number. For this preference to be sensible, however, we have to assume that hygienists are consistent in defining the population that should be sampled. If at large plants they are more likely to sample only the workers who are likely to have high exposures while at small plants they also sample workers who have even a small chance of an excessive exposure, then the use of percentages will systematically overstate the control success at small plants. Review of the hygiene manual and contact with hygienists is necessary to clarify these issues. For the purpose of targeting OSHA health inspections, the most relevant measure is the number of workers overexposed.

Even, for the moment, assuming an emphasis on focusing on the percentages instead of the absolute numbers, several choices are possible. The percentage of workers exposed to levels above the PEL is one obvious candidate and the leading one if the focus is on compliance per se. However, that measure does ignore important information: how much above or below the PEL were the exposures? No single number can convey this information. A weighted average of exposures will take account of the variation, i.e., a very high exposure will raise the average; however, once we have the average, we won't know whether it came from many moderate exposures or from a few very low and very high ones. Another choice could be to look at the exposure of the highest quartile or quintile. The best procedure will be to try the different methods and see if the results vary much depending upon which are used. For chemicals with thresholds, the proportion exceeding the PEL may be appropriate. The weighted average may be best for carcinogens.

Up to this point, we have focused on the conceptual problems with different measures of firm performance in controlling toxic exposures, touching only lightly on the validity and reliability of the measurements themselves. These issues deserve more systematic review.

Some of the problems arise from the sampling process itself. First, there is a sampling error associated with the measurement instruments and the laboratory analyses. OSHA has constructed .95 confidence limits for the measured exposures. In most cases, these "sampling and analytical errors (SAE)" extend about 10% to 20% below the measured exposures. OSHA will not cite an overexposure unless that lower confidence level exceeds the PEL.

We have already alluded to a second source of variability in sampling results. Sometimes inspectors may sample only the most heavily exposed workers; at other times they may sample from the full distribution of exposures. In addition, their assessments of the number of workers "similarly exposed" to the workers they sample may be subject to error. A third possible factor that can distort the true measurement of exposures is the hygiensist's failure to identify exposures that do exist or to sample exposures that are not the highest in the workplace.

There are a number of other factors, not related to the sampling practices, but rather to variability in the actual level of exposures. The first is that exposures may vary due to variations in the level of plant operations. When a fume-emitting operation is performed once a day, exposures will be less than when it is performed twice a day. Inspections may happen to be conducted on days when exposures are higher or lower than normal. Hygienists usually do ask managers and workers whether conditions are normal, and they often reschedule inspections when emissions are abnormally low. However, there is undoubtedly a range of variation that lies below the level at which that occurs. In some cases, the management undoubtedly tries to take quick measures to reduce exposures at the time of the inspection.

Exposures sometimes vary with the individual worker who is involved. Some welders and solderers put their face very close to the metal and experience higher exposures. Spray painters stand in different positions in their booths. The particular operation being performed the day of the inspection may involve greater or lesser hazards (e.g., a welding flux with more cadmium than usual or a paint with a lower lead content) than the usual operation. The efficacy of the control technology also may be subject to variations. For example, a firm may test its ventilation system every 10 days because it begins to clog up at about thattime. If the inspection occurs on day 10, the measured exposures may be higher than they would have been on day 1. This type of variation in control technology efficacy, as well as in the behavior of workers, is subject to management control.

As a result of all of these factors, measured exposures may not be accurate indicators of the usual exposures levels found at the workplace. Comparisons of the exposures at different workplaces or of the same workplace at different points in time may vary as a result of these fluctuations, rather than as a result of actual differences in average exposure levels. The existence of these sources of variation will tend to reduce the proportion of the variation in exposures that we will be able to explain with the independent variables that we have.

The OSHA Inspection System

An understanding of the OSHA inspection system should clarify the nature of the data that are being reviewed in this study. OSHA conducts four main types of inspections: general schedule, complaint, follow-up, and accident investigations. Complaint inspections are conducted in response to a request for an inspection from an employee, a union representative, or any one else. Until 1976, complaints had to be in writing in order to ensure a response. At that time, in response to the Kepone disaster, OSHA instructed its Area Offices to respond to verbal complaints as well. As a result, complaint inspections mushroomed and threatened to eliminate other inspection types in some offices. OSHA responded in 1979 with a policy that distinguished between written (formal) and unwritten (informal) complaints, and which established a procedure for contacting the employer about the complaint to see if it could be resolved without an inspection.

OSHA also investigates workplace fatalities and catastrophies (accidents hospitalizing five or more workers). By law these most be reported to OSHA within 24 hours. These have not, however, ever comprised more than about 2% to 4% of all inspections. Follow-up inspections are used to check on compliance when a prior inspection found violations. OSHA's policy on follow-ups has varied over time. For one period, all citations of "serious" violations were supposed to be followed up. At other points, the choice was more discretionary. General schedule inspections have been conducted according to various formulae; however, they have all had the effect of directing OSHA safety inspectors to the larger workplaces in industries with high injury rates. Table 1 shows overall OSHA inspection activity by type of inspection from July 1972 through September 1979.

Health inspections are generated by a somewhat different process. Although some accident investigations are generated by health hazards (e.g.,a break in a chlorine line), this is quite rare. Often, health inspections are scheduled as a result of a referral by a safety inspector, who has noted some condition that he or she believes should be investigated. (In some cases, primarily noise, the safety compliance officer is trained to conduct tests himself.) In these cases, the pattern of referrals will be influenced by the targeting system for safety inspections, described above. In addition, several different health inspection scheduling programs have been used. In 1972, OSHA began a Target Health Hazard Program, which included carbon monoxide, silica, lead, asbestos, and cotton dust. Noise and carcinogens were added in July 1974. (President's Report on Occupational Safety and Health (PROSH), 1974, p. 25). By 1976, this program had been discontinued and the industrial hygienists were responding to referrals and to the growing number of complaints. By 1979, as the number of complaint inspections was restricted, a new health inspection targeting program was introduced which focused on larger firms in industries which were known to use larger numbers of potentially hazardous substances. In late 1982, Regions 1 and 3 had developed experimental programs utilizing their own past experience in different industries to guide their health inspections. Over this time the number of OSHA hygienists increased from 68 at the end of 1972 (PROSH 12/73, p. 33) to 117 at the end of 1974 to over 450 in 1979. Since then the number has declined; for fiscal 1982 OSHA reported 378.

Health inspections were more heavily affected by the upsurge in complaint inspections than safety inspections. Table 2 shows the distribution by inspection type of the lead, silica, and asbestos inspections which were reported in the OSHA Management Information System. From only about 20% of all health inspections in 1973 and 1974, complaint inspections rose to over 70% in 1978. For trichloroethylene (TCE), which was not a target health hazard, the proportion of complaint inspections was higher to begin with and the increase in it less steep.

Note also that the increase in the total number of inspections was much greater for TCE than for the other three substances. In part, this reflects the THHP program's emphasis on the latter, but it also results from the use of state industrial hygienists working under contract for the THHP. This fact helps to explain why the total number of health inspections hasn't increased nearly as much as the number of OSHA hygienists. The growth in federal hygienists arose partly from a substitution of federal for state officials. Other data on violation rates are shown in Tables 3 and 4.

The Data in the OSHA Management Information System (MIS)

For each inspection, the Area Office is required to submit several forms to OSHA headquarters for submission to the OSHA MIS. One form (called the OSHA-1) gives the basic information about the workplace inspected (name, address, size, industry, etc.), along with the type of inspection (e.g., complaint or general schedule, health or safety) and the date. If there were any citations issued, another form is submitted explaining what they were, the penalties assessed, and the abatement dates given. Except in the case of noise and a few other substances where direct reading instruments are used to measure exposures, all of the samples that hygienists collect are sent to the OSHA laboratory in Salt Lake City. For measuring any individual's exposures, the hygienist may have collected several charcoal tubes or filters, each covering a few hours. The lab measures each tube or filter and sends the results back to the Area Office. The IH, who knows which tubes should be aggregated to measure a single exposure, calculates the time-weighted average to see if the exposure limits were exceeded. If they were, the citation form is sent in at that time. In addition, the actual sampling results are also supposed to be sent in by the Area Office on the OSHA-35 form.

In fact, the test sample data is often not submitted to the MIS by the Area Office. The underlying reason is that the data has not played any significant role in the agency's operations. In particular, OSHA field personnel have no incentive to submit the data; unlike the OSHA-1 form and the citation data--which are used to assess the work of individual inspectors and Area Offices--the exposure data are not used in that fashion. Moreover, top OSHA officials have not (until recently) found other uses for the information which would have given them the incentive to make sure that field officials complied with the requirement to submit it.

Overall, we know that during the period from the beginning of the MIS in late 1972 (OSHA inspections began in April 1971) through March 1979 (when a different data system was introduced), there were 47,309 inspections that were classified on the OSHA-1 form as health inspections. Of these, the MIS has test sample data for 26,844 (56.7%), leaving 20,844 without sample results. Even for those with sample results, we have no way of knowing (without going back to the Area Office file cabinets) whether all of the samples were reported. One reason why no test samples are reported could be that no samples were taken; for example, an IH may have found that the operation emitting fumes had been shut down. Also, for some hazards, OSHA has requirements for work procedures rather than for exposures limits. David Smith of the OSHA Office of Field Coordination estimates that these cases are unlikely to comprise more than 5% to 10% of all health inspections. Thus even if we subtract 10% from 47,309, we should still expect to find almost 42,600 inspections with sample data.

Of the 25,844 inspections with test samples, 5711 had only noise samples, 11,967 had only toxic substance test samples, and 6,256 had both. (Actually, we distinguished toxic substances from physical agents--the 8000 series of toxic substance codes--but noise comprises over 95% of these.) A minimum estimate of the percentage of toxic substance inspections for which data is submitted to the MIS would come from dividing the total number of inspections with toxic substance samples (20,754) by the 42,600 inspections where we believe that sampling took place. This would give us 48.7%. A maximum estimate would be based on two assumptions: first, that the inspections which are in the MIS with only noise samples did not, in fact, have toxic substance samples; and second, that the missing inspections included pure noise inspections in the same proportion to toxic substance inspections as for the cases in the MIS. The result, dividing 20,754 by 33,304, gives 62.1%. The latter calculations are based on the assumption that noise samples are no more likely to be submitted to the MIS than toxic substance samples. Forty-six percent of the inspections with test samples in the MIS included noise samples. Staff at the OSHA Office of Field Coordination stated that it was plausible that about 46% of all health inspections included noise samples. (Interview with MaryAnn Garrahan) Thus, it is plausible that both types of inspections are equally likely to be submitted to the MIS. It seems reasonable to conclude that from 1972 to 1979 there is test sample data in the MIS for about 50% to 60% of the inspections in which toxic substances were sampled for.

Another estimating method is to compare the number of samples analyzed by the OSHA laboratory with the number reported in the MIS.

Unfortunately, the lab does not have data for the period before 1979 in an accessible form. In addition, the lab's information system keeps tabs of the number of analytes (e.g., charcoal tubes or membrane filters), not the number of workers sampled or the number of inspections. Very often, the sampling of an individual worker requires more than a single analyte, sometimes more than five. However, it is possible to compare lab data with the MIS because, at least in its pre-1979 form, the MIS includes information on the number of analytes for each worker. For example, in 1978 the MIS had 388 inspections with test results for asbestos, which were based on 3,583 analytes. For silica, there were 337 such inspections with 3,579 analytes. For fiscal 1980, the OSHA lab had 5,736 asbestos analytes and there were 304 inspections in the MIS. For silica, the lab had 5,078 analytes and there were 315 inspections with test data in the MIS. If we assume that both the proportion of inspections reported to the MIS and the number of analytes per inspection remained constant, this method would also suggest that 50% to 60% of the test results are submitted to the MIS. (For asbestos, we would have expected 5736 divided by 315/388 analytes or 7326 instead of the 3583 we had in the MIS for 1978. For silica, we would have expected 5078 divided by 315/337 or 5437 instead of the 3579 we had. These are 49% and 66% of the numbers expected with full reporting.)

More important than establishing the number of missing inspection results is ascertaining the nature and magnitude of any bias that their absence creates. One check was to look at the inspections with a citation for any of the toxic substances covered by OSHA's regulation 1910.1000 (which includes almost all of them, except for those for which new standards have been established since 1971), and see how many of them did not have test samples for any substance covered by that regulation. Out of 4,047 inspections with such citations, only 784 lacked test samples for toxic substances. Eighty-one percent did have test samples, a much higher figure than for all inspections for toxic substances. These numbers indicate that there is a bias, that the data from inspections with violations are more likely to be submitted to the MIS. (Interestingly, for noise citations, the figure was 55%, which does not suggest any significant bias. One implication is that although the percentage of inspections in the MIS which show violations is low, the test sample data actually overstate the true percentage to a considerable extent. To be specific, the citation data is correct, but the citation data do not specify which substance was involved; only the test sample data do that. Substance-specific estimates of violation rates will be overestimates.

How does that finding affect this analysis? It depends upon whether that bias is correlated with the variables in the analysis. For example, suppose that all of the bias comes from certain Area Offices which never reported inspection data when there were no violations. Suppose that all of the inspections for a certain industry were handled by those Area Offices; the result would be that inspections there would show violation rates of 100%. Further tests can investigate how the pattern of non-reporting correlates with other variables. (I am beginning some of this work with the help of OSHA staff.) My guess is that these problems will usually not be major, with the important potential exception of a changing bias over time. At present, the only data bearing on this question are the figures in Table 5 showing the total number of health inspections by year, according to the OSHA 1 form, and the total number of inspections with sample data. As the

Table shows, except for 1972, the proportion of inspections with sample data submitted to the MIS was higher in the earlier years, but declined to 50% by 1977, a level that remained steady through the first part of 1979. If this decline indicates an increasing reluctance to submit data for inspections without violations, then the MIS data will give an upward bias to our measures of the changes in exposures from 1974 to 1977. The bias may mask improvements thatcould have occurred. Further comparison of test sample data with citation data for each year should clarify the nature of the reporting bias over time. Looking at the data for each Area Office by year should also be helpful.

Data and Methods

A. The data used in this analysis are from the OSHA Management Information system (MIS). In March 1979, OSHA changed the method for storing data from health inspections. This analysis looks at the data from the earlier period. The major difference is that the 1979-1982 data include the exact level of each measurement of toxic exposures. The 1972-1979 data place exposures in one of five categories: below the permissible level (PEL); 1 to 2 times the PEL; 2 to 3 times the PEL; 3 to 4 times the PEL; and more than 4 times the PEL. Because about 80% of the exposures fall below the PEL, the more recent period provides considerably more information.

B. The data for the 1972-1979 period are organized with a main record for each inspection (essentially the data from the OSHA-1) and numerous sub-records, each representing an individual test sample. For data storage reasons, we analyzed only the first 30 test samples for each inspection. This decision affected only 1% to 2% of the inspections. For example, of the 1986 silica inspections, only 34 had more than 30 test samples and only 15 had more that 40.

C. Data from 1972-1979 included accident rates in only a few percent of the cases and firm size (as opposed to establishment size) in only about 10%. Therefore, those variables were not included in the analysis.

D. The union status was also missing in about one-third of the cases, almost entirely in the pre-1976 period. Because this variable was believed to be important, a discriminant analysis procedure was used to predict - on the basis of the other variables - whether there was a union. By far the most important predictor was whether a worker accompanied the inspector (the WALK variable, for which information was always available). For those cases for which we did know the union status, WALK correctly predicted that status for 80% of the cases. Adding other variables raised the correct classification to about 85%. Thus, for a substance in which the union was unknown in 30% of the cases, we can expect this procedure to incorrectly classify 4.5% (30% x 15%) of the entire sample.

E. The inspections were organized into separate files for particular toxic substances. Thus any inspection that involved test samples for silica was included in the silica file. If the same inspection also included tests for asbestos, it would be included in the asbestos file as well. In each case, however, the measure of performance (i.e. the results of the test samples) pertain only to the substance of that file.

Table 6 shows the proportion of the inspections for each substance which involved tests of other substances.

Table 6

Proportion of Inspections with Sampling for Other Toxic Substances

		Asbestos	Lead	Silica	Trichloroethylene
Number of Other Toxic Substances Tested	0	65.5%	29.8	34.4	22.1
	1	15.9	19.0	21.2	17.2
	2	6.3	15.1	13.3	15.8
	3	4.2	10.0	10.0	12.4
	4	2.8	7.0	6.4	8.4
	5	1.6	4.9	4.3	5.8
	6	1.2	4.1	3.3	3.3
	7	0.7	1.9	2.0	4.0
	8	0.5	2.1	1.6	1.8
	9	0.5	1.8	0.7	2.5
	10	0.2	1.4	0.8	1.3
	11+	0.7	3.0	2.2	5.4

Adding up the numbers of inspections for each substance gives 6696 inspections. However, because more than one of these four substances may have been sampled for on a single inspection, the total number of different inspections involved is less than 6696. Of the four, only lead and silica are frequently found together. My best guess would be that fewer than 10% of the inspections are duplicates with almost no chance that it is greater than 20%. Thus these data probably represent over 6000 separate inspections and certainly represent over 5300.

F. In addition to the statistical analysis on the 1972-79 data, interviews were conducted with industrial hygienists at three Area Offices in 3 different Regions. One objective was to gain more insight into the practices that IHs employ in the field. In addition, 10 IHs were interviewed about 87 inspections they had conducted since 1980. Some of the information they provided about costs of compliance with citations, the age of plants, and the extent of employer information about hazards is discussed in this report. The inspections selected for review were chosen to overrepresent cases with violations.

Definition of the Variables

ANYCIT - If there was any citation listed on any of the test sample data blocks for that substance, ANYCIT took the the value 1.

SCIT - If there was any serious citation listed on any of the test sample data blocks for that substance, SCIT took the value 1.

SEVEMP - This is the number of employees found to be exposed to any level about the PEL (permissible exposure level) for that substance. For each test sample, the industrial hygienist estimates the number of workers similarly exposed. If sampling of one worker showed an exposure above the PEL and one other worker was similarly exposed, then SEVEMP would be equal to two.

SEVPER - This is the proportion of all workers tested who are found to be exposed above the PEL (i.e. SEVEMP divided by the total number of workers whose exposures were measured). In the example above, if an additional four workers were sampled and their exposures were all below the PEL, then SEVPER would be two divided by six or 0.33.

WSEVPER - This is the weighted version of SEVPER. For 1972-79 data, exposures were grouped in 5 categories: below the PEL, 1 to 2 times the PEL; 2 to 3 times the PEL; 3 to 4 times the PEL; and more than 4 times the PEL. (For all of these, time weighted average and ceiling violations were combined.) For each category, the midpoint of the range was chosen. For example, if all exposures were below the PEL, WSEVPER was 0.5. If all exposures were 1 to 2 times the PEL, WSEVPER was 1.5. If half were below the PEL and half were 1 to 2 times the PEL, WSEVPER was 1.00. WSEVPER could range from 0.5 to 4.5. A WSEVPER of 4.5 would mean that all of the workers sampled were exposed to more than four times the PEL.

UNION - This is whether a union represented employees at the worksite. For cases where union status was unreported, it was predicted as described above.

METRO - METRO is equal to 1 if the worksite is located in a metropolitan area (i.e. a standard metropolitan statistical area or SMSA). This was determined by matching state and county codes with the SMSA descriptions.

NUMSUBS - This is the number of other toxic substances for which test samples were taken during the inspection.

SEVSUBS - This is the highest severity level of the exposures for any other toxic substance for which test samples were taken during the inspection. Again, TWA and ceiling violations were combined so that SEVSUBS could range from 0 to 4. When NUMSUBS was zero, SEVSUBS also had to be zero.

Y74-Y79 - These are the dummy variables for the calendar year in which the inspection began (some inspections ran for more than 1 day). The coefficients show the difference between that year and the excluded category, inspections which occurred in 1972 and 1973.

SIZE - These are dummy variables for the size of the establishment. The coefficients show the difference between that category and the excluded category, establishments with fewer than 20 workers. SIZE20 includes those with 20 to 49 workers; SIZE50 with 50 to 99, and so on.

Industry - For each substance file, any 4 digit SIC code with more than 30 inspections was included as a separate category. If there were such codes, the remainder of the inspections in the 2 digit SIC code were labeled as OTHER. If there were no 4 digit codes with 30 inspections, 2 digit SIC codes with 30 were used. If there were not 30 inspections in the 2 digit SIC, the categories of SICCON (construction), NONDUR (SICS from 20 through 29), SICDUR (SICS from 30 through 39) or NONMAN (other nonmanufacturing) were used. NONMAN is the excluded reference category for the SIC variables.

INTYPEC and INTYPEF - These refer to complaint and follow-up inspections, respectively. The reference category is the general schedule inspection category.

SPRIOR - If an establishment had been previously inspected, but that inspection had not involved any sampling for the substance in question, then SPRIOR was equal to 1.

Table 7

Short Definitions of the Variables

ANYCIT - Dummy variable equal to 1 if there was a citation for overexposure for that substance

OVEREX - Dummy variable equal to 1 if there were any workers exposed above the permissible exposure level (PEL) for that substance

SEVEMP - Number of workers exposed above the PEL for that substance, including those "similarly exposed" to workers who were sampled

SEVPER - Percentage of workers sampled and "similarly exposed" who were exposed above the PEL

WSEVPER - A version of SEVPER weighted for the severity of the overexposures; ranges from 0.5 (no one exposed above PEL) to 4.5 (all workers exposed to more than 4 times the PEL)

METRO - Dummy variable equal to 1 if plant is in a standard metropolitan statistical area

PREDICTU - Dummy variable equal to 1 if a union represents workers

NUMSUBS - Number of additional toxic substances for which sampling was also conducted on that inspection

SEVSUBS - If NUMSUBS is non-zero, this is the highest severity level (in relation to the PEL, i.e., less than the PEL=0, 1 to 2 times the PEL=1, 2 to 3 times=2, etc.) found for the other toxic substances

INTYPE(C)(F) - INTYPEC is the dummy variable for a complaint inspection; INTYPEF, for a follow-up

HPRIOR - Number of prior health inspections which sampled for that substance

SPRIOR - When HPRIOR=0, SPRIOR is a dummy variable for whether there had ever been an inspection at that workplace

Table 7 (cont.)

Y74-Y79 - Dummy variables for the calendar year the inspection began (e.g. Y74=1 if the calendar year was 1974); the coefficient gives the impact of being in that year instead of 1973

SIZE - Dummy variable for establishment size (e.g. SIZE20=1 if establishment size is 20-49 workers); the coefficient gives the impact of being that size category instead of the category with less than 20 workers

Findings: Introduction

The major test of the hypotheses presented above were made by using multiple regression analysis on all of the 1972-1979 OSHA inspection findings for four substances: asbestos, lead, silica, and trichloroethylene (TCE). Table 8 shows the levels of the dependent variables for these substances.

Table 9 shows the R^2 and F statistics for regressions on each of the variables. (More complete regression results appear in the Appendix.) The R^2 describes the proportion of the variation in the dependent variable that is explained by all of the independent variables. In these cases the R^2 ranges from about 0.05 to 0.25. Clearly, most of the variation can not be explained by the factors considered here. We have already described many of the factors that make measured exposures less than perfect as indicators of plant performance in controlling exposures. Many studies of safety behavior have emphasized the importance of management concern and attention. We have no way to measure variations on this dimension. Explanatory power is also limited when 50% to 90% of the cases have the same level of dependent variable (i.e., no overexposure) while differing in the level of the independent variables. Especially for those cases with dichotomous dependent variables (e.g. OVEREX, ANYCIT), a logistic model may do a better job. It will be interesting to see whether the analyses of post-1979 data - for which we have more exact measures of exposures - provide different results. In any event, it is clear that the variables included are far from capturing all of the factors that determine success in controlling hazards.

Not only do the variables examined here explain a small proportion of the variation, but the F tests show that in some cases we can't easily reject the conclusion that all of the coefficients are zero. The "F" statistic provides a test of whether that hypothesis can be rejected. It is a positive function of both R^2 and sample size, which explains why the TCE general schedule regressions, using only 163 cases, had such low F statistics.

Despite these caveats, the analysis does provide new insights about several of the relationships we are interested in exploring.

It may be helpful to readers to review one of the regressions in order to clarify the interpretation of the coefficients. Table 10 shows the regression on all asbestos inspections using the dependent variable OVEREX (whether the inspection found any worker exposed above the PEL). Note that the constant term, at the end of the list of variables, is +.156. If all of the other variables are zero, then the value of OVEREX will be .156. As they are defined, this is the case of a firm without a union (PREDICTU=0) in a non-metropolitan area (METRO= 0) experiencing its first inspection (SPRIOR is zero). It is a general schedule inspection (INTYPEC and INTYPEF=0) which does not test for any other toxic substances (NUMSUBS=0 and thus SEVSUBS=0). The year is 1973 and the firm is not involved in manufacturing or construction (all of the years and industries listed in the regression are zero).

The coefficients tell how much each variable adds or subtracts, on average, to the likelihood that the inspection will find at least one worker overexposed. The first column of numbers is the coefficient, the second is the standard error of the coefficient, the fourth is the "F" statistic for that coefficient. (We can ignore the third column.) The coefficient is the effect of a 1 unit change in the independent variable on the dependent variable. Most of the independent variables take the value zero or one. For them, the coefficient is simply the impact of being in the stated category. For example, being in a metropolitan area reduced the likelihood of an overexposure by .065, a very major drop. Being in size class 100 (100 to 249 employees) increased the likelihood by .029. The SIZE100 coefficient, however, is not statistically different than the reference group of 1 to 19 workers. The F statistics (the square of the t statistic) would have to have been larger than 2.706 for there to be less than a 1 in 10 chance that a difference that large could have occurred by chance. For coefficients for which we have predicted the sign, 1 tailed tests are used; for others, two-tailed tests. Because of the exploratory nature of this study, we report significance at this relatively low level. With 42 variables in the regression, we could expect 4 to be significant at this level just due to chance.

Findings for Variables

UNION - The prediction that the presence of a union would contribute to lower exposures and fewer citations was generally not supported. In all of the regressions on OVEREX and USEVPER, the union variable (PREDICTU) never attained even a .10 level of significance with a negative coefficient. This was true for both GS and complaint inspections. The coefficient was positive more than it was negative, and the standard errors were almost invariably much larger than the coefficients.

METRO - The Metro variable was included in the belief that plants in non-metropolitan areas would have higher exposures for two reasons: reduced information and access to technical capabilities on the part of management and reduced labor market opportunities for workers, leading them to accept high exposures more easily.

In the regressions for GS asbestos inspections, METRO was significant at the .001 level for both OVEREX and WSEVPER. For silica, it was negative in both, but not significant; for lead, it was positive in both, but not significant; and for TCE, it was positive and significant in one regression. In the regressions on complaint inspections, METRO was negative and insignificant in all of the asbestos and silica regressions, negative and significant at the .001 level in the lead regressions, and insignificant in both TCE regressions.

The findings are mixed, but there is some support for the hypothesis that plants in non-metropolitan locations have higher exposures. Substantively, METRO reduces the likelihood of finding overexposures in asbestos inspections by .10 or .06, very large amounts when you consider that the average likelihood is only 0.16 or 0.17. For lead the reduction was .04, about 12% below the mean; for silica, .03, about a 6% reduction.

It seemed plausible that there might be interactions between metropolitan location and union status because the presence of a union was presumed to remedy some of the information and bargaining power defects. If so, then a union's presence would make more of a difference in a non-metropolitan area than in an urban area. Such an effect did seem to occur with regard to general schedule inspections for asbestos, as the figures on the following page show:

		Metro	No	Yes	No	Yes
		Union	No	No	Yes	Yes
Anycit	Yes		6	7	6	14
	No		25	92	35	162
	% Yes		19.4%	7.1%	14.6%	8.0%

Thus, in metropolitan areas unionized workplaces did not have lower citation rates, but in non-metropolitan areas they did. For other substances, however, the differences were trivial or disappeared.

NUMSUBS (the number of other toxic substances for which tests were conducted) - This variable was included to test the hypothesis that there were economies of numbers in the control of toxic substances. With two, rather than one, toxic substances, it might seem worthwhile to a firm to install improved ventilation; in addition, a firm that uses may substances is more likely to invest in informing itself about them. Of course, the extent of any economies depends on the specific substances used and on where they are used.

The number of substances OSHA tests for is not a perfect measure of the number that are actually in the workplace. The disparity seems likely to be greatest in complaint and follow-up inspections, where the hygienist may focus on the hazards that have triggered the inspection. However, the findings below show that NUMSUBS was the same size in both the GS and the all cases regressions.

In all of the regressions, NUMSUBS is negative, as predicted. It is significant at the 0.05 level in both of the asbestos GS regressions and in one of the complaint regressions. For silica, it is significant at the 0.10 level for one of the GS regressions; for the complaint regressions, it is significant at the 0.05 level in one and at

0.10 in the other. For lead, it is significant at the 0.05 level in both GS regressions and at the 0.001 level in both complaint regressions. NUMSUBS was not significant in any of the TCE regressions.

It is possible that the causation runs both ways with NUMSUBS. Thus, if hygienists knew that exposures to one substance were high, they might be more inclined to sample other substances. Generally, however, hygienists do not know the results of the tests until long after the inspection. The exceptions are substances - like solvents - for which indicator tubes are used. Trichloroethylene falls in this category; two way causation would tend to weaken the relation with NUMSUBS. Thus the finding that NUMSUBS was usually insignificant in those regressions suggests that two way causation may be a problem. Of course, it is possible that hygienists have other cues that can predict whether excessive exposures will be found.

Perhaps a more fundamental problems with NUMSUBS stems from the observation made by several hygienists that the number of substances sampled for and the number of workers sampled tends to be greater among inexperienced IHs. Because they are unsure of themselves, they tend to sample everything. The result of such "fishing" would tend to be a negative correlation between the number of substances sampled for and the probability that any one will show an overexposure.

Even if the NUMSUBS findings are valid, their substantive significance should not be overstated. Rather consistently, an additional substance tested for reduced the proportion of inspections finding overexposures by .01 or .02, a reduction of from 2% to 8% depending on the substance. (For example, .1602 of all of the asbestos inspections found overexposures; .008 constitutes a 5% reduction.)

SEVSUBS - It seems reasonable that employers who allow excess

209

exposures to one toxic substance are more likely to allow excess exposures to others. SEVSUBS is the highest severity exposure for those other substances whose presence is noted by NUMSUBS. SEVSUBS ranges from 0 to 4.

In the regressions, its coefficient was positive, as expected, in every one of the regressions. In the GS inspections, it was significant at the 0.001 level for both lead and silica regressions and for one of the TCE regressions. For one asbestos regression, it was significant at 0.05; generally, this variable performed least well with asbestos. In complaint inspections, the asbestos results were insignificant, one of the silica regressions was significant at the 0.10 level, and one of the TCE regressions was significant at the 0.05 level. Only the lead regressions remained significant at the 0.001 level. Substantively, a 1 unit increase in SEVSUBS (e.g., from 0 to 1 or from 1 to 2) increased the weighted severity measure (WSEVPER) by from 5% to 22%. For example, the mean value of WSEVPER for trichloroethylene was 0.715; a 1 unit increase in severity increased WSEVPER by 0.156.

The reason why the lead results are so strong is probably because lead is often emitted along with other substances (e.g., arsenic, copper). Thus an overexposure to copper or arsenic is likely to come from the very same operation in the same location, rather than from a different operation in another part of the plant. The overexposure is a result of the same lack of controls rather than an indication that if one operation is not well controlled others are likely to be hazardous as well.

Establishment Size

Larger establishments and larger firms were expected to do a better

201

job of controlling exposures than their smaller counterparts. Unfortunately, the firm size categories on the OSHA form were usually left blank, and we have not yet been able to fill in the data from independent sources. Therefore we will look only at establishment size.

Because it was not obvious that the relation between size and performance is linear (e.g., for accident rates, the highest are found among firms with 50 to 100 employees), seven establishment size categories were constructed. Figure 1 shows the results for GS inspections for silica, lead, and asbestos for three different measures of worker exposure. The reference group comprised plants with less than 20 workers. Very few of the differences between that group and the other size categories were statistically significant, as Figure 1 shows. However, several general findings are apparent. In every case but one, the highest value is in the size categories between 50 workers and 500. In every case, the lowest value is in either the biggest size category (5 cases) or in the smallest (4 cases). It was expected that larger workplaces would do relatively better on the SEVPER and WSEVPER measures, for the reasons described below, and this was borne out for silica and lead. The relatively low exposures at the smallest workplaces, especially for WSEVPER, were surprising. At least by these measures, small workplaces do not do the worst job of controlling exposures. The results for complaint inspections show less of a pattern. Although the middle size groups have almost all of the high points, they also have most of the lowest exposures; even fewer of the size coefficients are statistically significant.

Interpretation of these findings is hampered by the ambiguous notions of performance represented by the dependent variables. If an overexposure of a single worker triggers a citation, a large workplace may look as bad as a small one, even if the former has successfully protected 99 other workers, while the small plant has protected only 1 other worker. The relationship between plant size and the number of workers potentially exposed surely varies among operations. In some it is invariant to size; in others, it may grow proportionally with size. Ideally (at least for our purposes), the industrial hygienist would take these differences into account. Even if he directly samples a smaller percentage of the exposed workers at a larger plant, he should adjust in his calculation of the number of workers who are similarly exposed. The result should be that there is no artifact-caused correlation between the number of workers whose exposures are tested (including those who are "similarly exposed") and the percentage of workers who are overexposed.

We did calculate this relationship for those cases in which there had been at least one worker overexposed (i.e., SEVEMP > 0). Dividing SEVEMP by SEVPER (the percentage of workers tested who were exposed to levels about thePEL) recreated the total number of workers who were sampled or who were "similarly exposed" (TESTEMP). For the four hazards, the correlations between TESTEMP and SEVPER were as follows:

	Asbestos	Lead	Silica	Trichloroethylene
Correlation	-0.0626	-0.064	-0.0865	-0.2112
N	259	777	953	107
Prob. Value	.158	.001	.011	.014

(Correlations of TESTEMP with WSEVPER were similar, except for trichloroethylene, for which the sign became positive.) This negative relationship could simply be indicating that, for any given exposure, as hygienists sample more widely they will find a smaller percentage of those sampled to be overexposed. It could also indicate that when more workers are potentially exposed, employers do a better job of controlling exposures. It is also plausible that when large numbers of workers are exposed, hygienists are more likely to confine their sampling to the most severely exposed. If only 5 workers were potentially exposed, the hygienist might sample all of them. If 50 were exposed, he still might sample only 5; but rather than sample from the full distribution of exposures, he might sample only the5 most severely exposed. (Discussion with hygienists indicates that there is no uniform procedure in this regard.) If so, the sampling strategy would bias the relationship between number of employees tested and the percentage overexposed (SEVPER) in a positive direction. The fact that the correlation is negative suggests either thatthis phenomenon does not exist or that it is outweighed by the other factors pushing the relation in a negative direction. At this point we can't distinguish which explanation is correct.

The negative correlation between the number of workers tested and the percentage found to be overexposed may bias the findings about establishment size. It seems plausible that establishment employees and the number of workers tested (TESTEMP) are positively correlated. In fact, as the figures on the next page indicate, while this is true for silica and especially TCE, it is not true for lead or asbestos.

Correlation Between Number of Workers Tested (TESTEMP) and Establishment size (ESEMPL)

	Asbestos	Lead	Silica	TCE
Correlation	+.0271	-.0009	+.1043	+.3955
N	259	777	953	107
Prob Value	.332	.490	.004	.000

However, when we look at the mean number of TESTEMPs in each size class (seeTable 11), we see that the lack of correlation for lead is apparently due to the absence of a linear relation; TESTEMP declines above size class five. The tendency of TESTEMP to increase with size is apparent. Given the positive association of TESTEMP with size and its negative association with the dependent variables, the failure to include it as an independent variable will bias the effects of size toward zero. Further research should investigate the sensitivity of the results to outlier (and probably erroneous) values - for example, one lead and one silica inspection each claimed that several thousand workers were similarly exposed. The foregoing problems, along with the absence of a firm size variable, should induce caution in drawing general conclusions about performance. However, we can conclude that larger firms are not less likely than small ones to have at least some workers exposed above the PEL; however, both are less likely to have overexposures than workplaces in the middle size ranges. When the percentage of workers sampled who are overexposed becomes the measure of performance, the largest firms usually improve their relative performance.

Industry

The levels of exposures at a plant are certainly dependent upon the types of operations which generate the exposures as well as the particular equipment used. Unfortunately, information of this nature is not available from the OSHA MIS. The only relevant piece of information it gives is the 4-digit SIC code. Ideally, industries could be combined into categories based upon similarities in the principal operations which generate a particular type of toxic exposure. That task proved beyond the scope of this project. However, SIC categories have useful properties because they are also used in economic impact studies of standards and in OSHA's own health targeting system.

The differences among industries probably reflect, in part, differences in the average costs of reducing exposures. For hazards like asbestos, for which estimates of compliance cost have been made for different industries, it is possible to test whether exposures are higher in industries where the average costs of compliance are higher. A recent Ph.D. dissertation by Carol Jones (Harvard, Department of Economics, July 1982) carried out this test for asbestos and found that every additional $100 in the engineering cost of compliance per employee increased the average exposure level by 0.7 fibers/cubic centimeter (p. 371). This is a surprisingly large response for such a small change in costs.

Several points about the industry findings in Table 12 are worth noting. First, the coefficients show the independent effect of industry, holding other variables constant. Second, the coefficients show how much higher or low the weighted severity was inthat industry than in the reference group; for asbestos, silica, and lead, the reference group was all inspections in an SIC above 3999 (basically all industries except agriculture, construction, and manufacturing); for TCE, it was all non-manufacturing inspections, including construction. Observe that for asbestos and lead and TCE, most of the manufacturing industries had higher weighted exposures than the reference group. For silica, the reverse was true. That means that the coefficient for SIC34 (fabrication), while it is not significantly different than the reference group, is significantly higher than it is for most manufacturing industries.

The Table shows the findings for the WSEVPER (weighted severity) regression on all inspection types. Recall that an inspection where all workers were exposed below the PEL would have a WSEVPER of 0.5; if a plant exposed all of the workers tested to a level of 1 to 2 times the PEL, WSEVPER was equal to 1.5; 2 to 3 times the PEL equalled 2.5. If 1/2 the workers tested were below the PEL and 1/2 were exposed to 1 to 2 times the PEL, WSEVPER would equal 1.0. In the regressions the difference between the best and worst industry averages about 0.5, the difference between this last case and full compliance.

What does the Table show? Is there any tendency for some industries to perform consistently well or poorly? The categories of SICNOND (2 digit SIC industries which begin with 2 that are not separately listed - e.g., furniture, textiles, food, lumber) and SICDUR (mainly instruments and miscellaneous manufacturing, SIC 38 and 39) did have consistently low exposures. Exposures to these substances in these industries are relatively rare, as are inspections; but these findings suggest that those exposures that do exist tend to be relatively well-controlled. Exposures in the electrical industry (SIC 36) alsoare better controlled than most.

Other industries show mixed patterns. Construction has the highest exposures for silica and lead, but the lowest among major industry groups for asbestos. Metal fabrication is quite high for asbestos, silica, and TCE, but low for lead. If we look at the OVEREX regressions (whether an inspection found an overexposure), we find that the high WSEVPER finding for construction--at least in the lead industry--is only slightly due to a higher proportion of overexposures there; mostly it is because the overexposures that do occur in construction tend to be especially severe. The OVEREX regressions are simpler to interpret than the WSEVPER regressions. Tables 13 and 14 show the results for lead for both general schedule and complaint inspections. The industry coefficients here show how much more or less likely inspections in the particular industry are to find any worker overexposed--compared to the reference group, holding other variables (e.g. plant size) constant.

If the key determinant of exposure levels is the cost of controlling different processes, then we should expect to find that the sign of the industry coefficient varies depending upon the processes used there for each particular hazard. A low variance in industry coefficients may indicate less diversity in the processes used in different industries. However, unless we can identify those procedures and the costs of controlling them, it will be difficult to determine whether factors like average profitability or industry traditions play any independent role. The best prospect is to use the studies commissioned by OSHA to estimate the compliance costs to meet proposed reductions in the PEL. Although these estimates pertain to lower PELs, it is likely that the industries which face high costs in achieving a lower PEL also face relatively high costs in meeting current exposure limits.

Additional evidence that industry differences reflect differences in the average costs of compliance are presented in Table 15. The average costs of compliance were those estimated by OSHA in its standards document on lead. There were eight industries for which OSHA cost data were available and for which more than thirty inspections for lead were reported in the MIS. The costs were the contractor's estimates, adjusted by OSHA, of complying with a 100 microgram/m^3 lead standard. (See the Federal Register, 11/14/78), Part IV, pp.52981-52985). During the period when this data was collected, a 200 microgram standard was in effect; however, it seems likely (although not certain) that the industries which would find it especially costly to comply with the new standard would also be the ones to incur the the highest costs to comply with the old PEL.

Table 15

Average Industry Compliance Costs Per "Exposed Worker" and the Effect of Industry on the Proportion of Inspections Finding Overexposures

Industry	Average Compliance Cost per exposed worker	Industry Coefficient on Overexposures* ("t" statistic)
SIC 3332 Primary lead smelting	$4000-5200	+.427 (3.21)
SIC 3341 Secondary lead smelting	$4300	+.195 (1.92)
SIC 3691 Battery manufacturing	$4000-4500	+.374 (3.94)
SIC 3362 Brass bronze and copper foundries	$3200	+.159 (1.55)
SIC 2711 Newspapers	$200	-.241 (1.90)
SIC 2751 Commercial printing-, letterpress		-.258 (2.05)
SIC 3411 Can manufacturing	$130	-.372 (2.97)
SIC 3321 Gray iron foundries	"no significant exposures"	-.231 (1.82)

See discussion in text

*The coefficient tells how much bigger or smaller the proportion of inspections finding workers exposed above the PEL is in that industry compared to the reference group - nonmanufacturing industries with SIC codes above 4000 - holding other variables constant. Thus, holding other factors equal, the proportion of inspections finding overexposures in primary lead smelting is .427 greater than in nonmanufacturing and .799 greater than in can manufacturing.

The figures I have used are the pre-tax annualized costs divided by the number of workers in those industries who were exposed to lead. Unfortunately, it was not clear what the criterion was for categorizing workers as exposed, e.g., did occasional exposure to low levels qualify?

Cost per exposed worker is probably the best measure for fitting the data into the employer's benefit-cost calculus. The benefits to the firm from reducing exposures - e.g., reduced compensation to the exposed workers - depend on perceptions as well as objective factors, but it seems plausible that the benefits per worker per unit of exposure are roughly equal across industries, at least in the absence of threshold effects. In that case, variations in exposures would be primarily determined by differences in compliance costs.

However, there is another possible theory about the role of economic concerns. Compliance might be a function of the firm's financial resources rather than a result of any balancing of the costs against the benefits. This second view would be consistent with organizational theories of firm behavior. Managers may have only the vaguest notion of what the benefits of reducing exposures would be. Abatement decisions will depend on which level of actors address them and what their decision rules are. Compliance actions may be undertaken as long as funds are available. In this perspective the key variable would be, not cost per worker, but rather costs as a proportion of capital investment or of total operating costs. (The results of this calculation will depend partly upon whether the denominator is drawn from the plant's figures or from the entire firm.) A 1000 worker plant where 20 workers were exposed to lead and the cost for eliminating their exposures was $80,000 ($4000 per exposed worker) might comply more readily than a 50 worker plant where 20 workers were exposed and the average cost was $400 per exposed worker. The $8000 cost might be more of an obstacle to compliance at the small plant than the $80,000 cost at the big plant despite the higher cost per worker at the latter.

Unfortunately, although we could use information about plant and firm size as a rough proxy for financial resources, we lack any data about plant-specific compliance costs that would enable us to test the different models at that level. However, the relatively weak influence of the plant size variable in our findings hints that financial resources can not be a major explanatory force. While larger firms may have better access to the capital markets, we are really talking here about a kind of intra-firm subsidy for occupational health measures that don't pay their own way in the eyes of the managers involved. Organizational factors (e.g., concern about corporate image) may justify such subsidies, but their extent seems likely to be dependant on the amount of funds involved, the impact on prices, and the competitiveness of the industry. If $4000 per exposed worker adds only 0.1% to total cost, and demand for the firm's product is highly inelastic, then organizational factors are likely to be least constrained and most influential. One testable implication is that the abatement cost per worker variable will have a bigger effect on the level of compliance in industries where the impact on product costs is higher.

Some additional information about compliance costs was gathered in reviews of case files with the industrial hygienists. In a little over half of the inspections with citations for overexposures to toxic substances the hygienist was willing to estimate what the costs to correct the violation would be. In several other cases, many follow-up inspections, the hygienist had an estimate of what the firm had spent to comply. Altogether, cost data were estimated for 17 firms, shown in Table 16. Several tentative conclusions can be drawn from these cases.

1) Lead and silica violations tend to be more expensive to abate than other toxic substance violations. Their cost is rarely within the range of OSHA's first instance penalties ($1000 per citation).
2) A minority of overexposures do seem to be cheap and easy to abate.

Table 16

Compliance Costs for Selected Inspections

Substances	Most severe Exposure (x the PEL)	# Workers Exposed Above PEL	SIC	Plant/ firm size	Estimated Compliance costs
1. lead	4.0	13	3341	110/large co.	Several hundred thousand dollars over a few years
platinum	3.5	12			
2. lead	16.26	15	3315	300/630	$100,000
3. silica			3272	19/50	$50,000-$100,000
4. silica	8.50	17	3321	100	$42,000 over 10 yrs
5. silica	2.30	7	3362	25	$20,000-50,000 No controls; unaware that "synthetic sand" was a problem
6. silica			2099	250	$20,000 to remove sand from raw product
7. lead			5511	28	$13,000 new spray booth at auto dealer
8. nuisance dust			3079	25	$12,000 dust collection system
9. lead	10.20	29	3231	200/3000	$10,000 waterfall for spray paint system
10. lead	1.14	6	3362	43	$5,000-$10,000 exhaust for grinders; but will use respirators for now
11. dimethyl formamide	3.85	11	2297	19	$5,000
12. carbon monoxide			3714	85	$500-$600
13. nuisance dust	1.66	3	3231	29	$500 local exhaust fan

Table 16 (cont.)

Substances	Most severe Exposure (x the PEL)	# Workers Exposed Above PEL	SIC	Plant/ firm size	Estimated Compliance costs
14. styrene	1.43	6	3732	15	$300 ductwork
15. silica	12.70	2	3599	17	$300 replacement of cracked sand-blasting helmet
16. carbon monoxide	1.29	15	5511	100	$100 extension of tailpipe exhaust ducts

In addition, one carbon black plant owned by a large chemical firm closed down after a citation (4.77 severity; 19 workers overexposed out of 60 employees), claiming that the compliance costs would be prohibitive.

Age of Plant

The MIS contains no data on the age of the physical plant. Interviews with IHs about their recent inspections did elicit estimates for the age of the buildings at more than 60 workplaces. These cases were grouped by 4-digit SIC and the age of the plant was compared with the highest severity level found in the inspection (i.e. the ratio of the highest exposure at the workplace to the PEL for that substance). Unfortunately, there were very few inspections of the same substance in any single SIC and for some of them the age data were not obtained. From the figures in Table 17 below, it is possible to discern a tendency for older plants to have higher exposures, but the data preclude any clear conclusions. For the six industries for which this matching could be carried out, five (all except the silica samples) did show that older plants tended to higher exposures. However, the data are so skimpy that this result should not carry great weight.

Inspection Type

Generally, complaint and general schedule inspections were indistinguishable in their independent effects on exposure measures and citations. Although the coefficient on the complaint inspection variable was usually positive, in only one case (ANYCIT for trichloroethylene) was it significant at the .10 level.

Evaluation: Have Exposures Declined? Can OSHA Claim Credit

Looking at the changes over time in the exposures found in inspections does not necessarily tell us whether exposures are, in fact, declining. It is possible that changes in reporting practices might account for any reported changes is exposures. In addition, we face the problem that inspections are not conducted randomly. Inspections in

218

Table 17

Do Older Workplaces Have Higher Exposures?: Plants Matched By Industry

	Severity of Worst Exposure	No. of workers Overexposed	Establishment Size	Age of Facility
SIC 3362				
1. lead	16.26	15	300	100
2. lead	1.14	6	43	60+
3. lead	1.00	0	2	5-10
SIC 2816				
1. lead	11.26	48+	180	150
2. lead	2.92	7	10	15
SIC 3231				
1. lead	10.20	29	200	15
2. lead	0.56	0	16	10
SIC 3321				
1. silica	8.50	17	72	30
2. silica	3.87	10	263	100
SIC 3341				
1. lead	14.88	8	70	30
2. lead	4.00	13	110	10
SIC 3732				
1. styrene	1.43	6	15	60+
2. styrene	0.18	0	9	15

Note: For source of data in the Table, see text.

early years may be disproportionately drawn from firms with higher exposures. Reductions in measured exposures over time could simply reflect more inspections of firms from low exposure groups or more extensive inspections which collect a greater number of samples. If we had been very successful in explaining the variations in exposures, non-randomness would be less of a problem. There are statistical techniques for trying to correct for the selection bias, but their potential success is unclear and they were beyond the scope of this project. (See Jones, pp.305 ff. for the use of these techniques.) Another difficulty is that findings of higher exposures could indicate improvements in OSHA's ability to identify high-risk workplaces, rather than a worsening of actual exposure levels. Again, to the extent that the identification is a function of the industry and size variables which are included in these regressions, there should be no bias. In fact, there was no new formal targeting program that could have incorporated new information. However, over time we would expect that inspectors do learn about the particular workplaces they inspect and that decisions about which to re-inspect would be informed by this learning. This plant-specific knowledge might not be reflected by industry and size averages. This discussion suggests that initial inspections and repeat inspections need to be analyzed separately.

Despite all of these problems, the findings of these regressions present some interesting results. Tests were run separately for GS and complaint inspections. If the findings for these two different methods for invoking inspections were similar, we would have somewhat increased confidence in the results. Table 10 presents the results for the GS inspections; Table 11 for the complaint inspections. The coefficients are for "dummy variables" which tell the effect of an inspection taking place in that year compared to the reference period of 1972 and 1973, holding other variables constant. The last provision, in effect, gives us the effect of the year at workplaces in the same industry of the same size.

For asbestos the GS results show that the ANYCIT rate increased from 1973 to 1976 and has remained higher through 1979. However, most of the measures of actual exposures have decreased, including statistically significant decreases for WSEVPER in 1975 and 1977. Interpretation of these results must keep in mind that the asbestos PEL was reduced from 5 fibers to 2 fibers in 1976. Thus, in the absence of any real changes in exposures, the measures of exposures above the PEL would probably have increased dramatically. (It is impossible to prove this because we do not know what the distribution of exposures below 5 fibers was. If they were all at 1 fiber, then the PEL change would have made no difference.) The fact that they did not - and that their are even signs of decline - is strong evidence of reduced exposures when the new standard took effect. The results for complaint inspections are mostly negative, but all insignificant. Again, the finding of no change implies a large improvement when the standard took effect. It is surprising, however, that in neither inspection type is there any indication of a trend. We might have expected exposures to be dropping steadily as the data for the 2 fiber PEL approached. Does that mean firms wait until the last minute before making the required changes? To some degree it may. My recent interviews with IHs revealed severa cases where firms cited for excessive exposures to lead are choosing to comply with respirator programs. The date for compliance with engineering controls was still over a year away and they wanted to delay as long as possible. However, when major capital investments are required, the plant's overall capitalreplacement timetable would probably dictate how soon the changes will be made.

For TCE, the GS results show sharp reductions in exposures. There is even some evidence of a trend, although the lowest exposures were achieved in 1977. IHs report that many firms have eliminated TCE from degreasing operations altogether, although that would not affect these findings unless the consequence was that, over time, the TCE operations come from non-degreasing operations which emit less vapors. In either event, the percentage of workplaces with overexposures (OVEREX) and the percentage of workers sampled who were overexposed (SEVPER) have both declined. However, it is noteworthy that the number of workers overexposed per inspection (SEVEMP) shows no change. This might mean that, although the proportion of plants with overexposures has gone down, those with them are overexposing a larger average number of workers. It is also possible that increased concern about the carcinogenic properties of TCE has lead IHs to sample more extensively, which could explain why SEVPER has declined even though the number of workers overexposed has not. The TCE results for complaint inspectons also indicated declines in exposures after 1973, although the reductions were neither as steep nor as steady as in the GS regressions.

For silica GS inspections, the findings are more mixed. In 1975 and 1976, SEVPER and WSEVPER showed increases, but the average number of workers overexposed went down. The interpretation here might be that the percentage of plants with overexposures remained constant, but sampling was restricted to more severely exposed workers. Thus SEVPER and WSEVPER would rise, while SEVEMP could fall. SEVEMP fell again in 1977. The results for complaint inspections showed a marked difference in the weighted severity (WSEVPER) findings. Instead of statistically significant increases, we find statistically significant decreases. Again, the OVEREX coefficients are negative, but not significant.

Lead is the only substance for which there was more evidence of increases in exposure than of decreases. For GS inspections, the average number of employees overexposed per inspection increased after 1973, peaking in 1976. The lack of change in the other measures implies that hygienists may have been sampling more extensively over time, which kept the percentage of workers overexposed constant even though the numbers increased. The results for complaint inspections show that the increase in the percentage of plants with overexposures became significant beginning in 1977, a finding that was not evident in GS inspections.

So far, we have not mentioned the ANYCIT results, which are not exposures results per se, but are at least in part, artifacts of OSHA's citation policy. One finding of this study was that OSHA became much more likely to issue citations for overexposures after 1975. This is shown for all four substances in Table 4. The implication is that ANYCIT is a biased measure of firm performance.

One interesting finding is that for each ofthe four substances, ANYCIT reaches its highest valuein GS inspections in 1976 and that each of the statistically significant exposure measures reach their lowest points in the following year. Does this finding reflect some effect of the enforcement process on exposures? Or are the two findings the results of separate and unrelated changes in inspection practices? In the absence of higher exposures in 1976, the higher citation rate implies a toughening of enforcement. Yet for this to have had an effect on exposure levels in 1977, either a strong deterrence factor must be at work--firms must learn about the toughening and be motivated toact to avoid citations--or many of the inspections in 1977 must have revisited the plants which had been cited in 1976 and which were now in compliance. It seems unlikely that very many of the plants with GS inspections in 1976 got another GS inspection in 1977. And, although trade associations often appear to convey information (according to IHs whom I interviewed), we have argued above that the threat of a citation seems unlikely to motivate firms to comply if their decisions are made primarily on financial grounds. Thus these findings remain puzzling.

Two other points should be noted. First, the number of GS inspections dropped sharply after 1975 and they came to rely more heavily on referrals from safety inspectors than on health hazard targeting. The effects of these changes are unclear, but they may have focused inspections more accurately on workplaces with overexposures. (A test of this would be to compare the Target Health Hazard Program inspections with other GS inspections during this period.) A second factor, discussed above, was the decline in the percentage of health inspections with test results submitted to the MIS. If this represented an increase in the practice of throwing away samples which didn't show overexposures, then the post-1975 overexposure rates would be biased upwards.

The MIS contains information about whether a particular establishment has been inspected before; however, it does not tell what type of inspection it was or what the findings were. To find that out, inspections with the same company name and same address must be identified. Although this can be done by the computer, a manual review is desirable because of mistakes due to misspellings and different ways of stating the same name or address. These reviews were undertaken for all of the four substance files. Seven percent of the asbestos inspections, 12% of the lead inspections, 2% of the silica inspections, and 5% of the TCE inspections were at workplaces which had prior sampling for the same substance. Some workplaces had had up to five such inspections. With this information, several variables were created: SPRIOR, a dummy variable taking the value "1" if it had had a prior inspection but no prior sampling for that substance; HPRIOR, the number of prior inspections on which sampling for that substance had been conducted; PWSEVPER, the WSEVPER measure for the most recent sampling for that substance (non-zero only when HPRIOR is non-zero); and PCITTY, a dummy variable for whether a citation was issued as a result of the prior health sampling.

In conjunction with the follow-up inspection variable (INTYPEF), these variables allow us to ask a number of questions about changes at particular workplaces over time. Unfortunately, at the time these variables were constructed, I was unaware of the extent of the missing data problem. Given that sample results are missing in 40% to 50% of all cases, I think that the effort to construct workplace inspection histories may not be valid at this time and thus that the findings for these variables should go unreported.

More generally, the findings for changes in exposures over time should be treated more skeptically than the other findings of this research if only because many changes that may bias the results are "correlated" with time. Nevertheless, the implied finding of a reduction in asbestos exposures is consistent with other evidence (see Jones, p. 109, Table 3-8) and thus gives some credibility to the findings. It should be possible to investigate many, although not all, of the potential biases. A clearer assessment of changes over time may be possible when that has been done.

Another issue that has been raised is whether firms respond to new information about the hazards of toxic substances by reducing exposures. A contrary view is that non-regulatory incentives are ineffective and that only the regulatory process is capable of effectuating those reductions. Fortunately, we can construct tests that compare changes in groups of hazards over time: 1) hazards for which recommendations were made to lower the exisiting exposure limits (but for which no new legal standards were promulgated); 2) hazards for whichno new recommendations were made; and 3) hazards for which lower PELs were established. If we assume that whatever changes occurred over time in reporting practices or inspections affected all groups equally, then this comparison should be valid. The assumption here is that recommendations to lower a standard provide information about previously underestimated hazards.

Reasonable proxies are available for measuring changing perceptions [illegible]e dangers posed by different substances. The American Conference [illegible] Governmental Industrial Hygienists (ACGIH) annually issues recommended threshold limit values (TLVs). Prior to OSHA, these were often incorporated in state regulations and the 1968 TLVs were incorporated by OSHA itself in 1971. Since then ACGIH has continued to make changes in its recommendations and these are widely known among industrial hygienists. In addition, NIOSH offers recommended exposure levels in the criteria documents that it issues. It is possible that NIOSH documents are sometimes viewed as "political", i.e., motivated less by new information than by a general interest in lowering exposures; however, they do focus more attention on the hazard.

We looked at OSHA inspection results for two periods: January 1, 1973 through December 30, 1975 and April 1, 1979 through July 21, 1981. For those substances for which OSHA had PELs in the early period, we identified those for which either ACGIH first proposed a reduction or NIOSH first recommended a reduction after 1974 and before 1980. Then we identified those substances for which at least 50 personal samples were taken in each period. Even that small minimum size led to a short list as Table 20 shows.

Of the ten substances, four had only small recommended changes - a shift from assuming workers were exposed for 10 hours (TWA) rather than 8 hours, which reduced the allowable hourly exposure by 25%. We focused on the 6 substances for which reductions of at least 50% had been suggested, although the nature of some of the changes made such calculations difficult. For example, the NIOSH recommendation for sodium hydroxide retained the TLV but changed it from an 8-hour TWA to a ceiling which can't be exceeded for more than 15 minutes. While compliance with the new standard could be achieved without any change in actual exposures, in practice maintaining a ceiling would be likely to require much stricter control measures.

For these six substances, the percentage of samples exceeding the PEL did fall from period 1 to period 2 from 17.10% to 8.90%. This difference is statistically significant at the .005 level in a one tailed test. We compared this reduction with the change for the substances which met the 50 sample criterion, but which had no recommended changes during or before the period in question. The percentage of test results exceeding the PEL also declined for this sample, from 10.39% to 3.69%. This drop was significant at the .05 level in a one-tailed test.

The difference between the two groups in the average reduction in excessive sample results was not significant; the confidence interval exceeded the difference in means several-fold.

We should be reluctant to draw conclusions about the reduction over time implied by these figures for both groups. Excluded factors may bias that result. Presumably, however, any biases should affect both groups equally and conclusions about the lack of difference between them should hold up.

Of course, the effects of new information may demonstrate considerable lags. Yet we probably should expect to find some effects of 1975-1979 changes in 1979-1981 tests. As another check, we looked at substances for which the first recommendedchange occurred in 1971 to 1974. For these nine substances (all of which met the 50 sample criterion), the change between the 1973-1975 period and the 1979-1981 period was an average of 5.57%, slightly less than in the other two groups. That result does notsuggest that a longer lag structure would show a greater impact of the appearance of new information.

Constructing a comparison group of substances which became subject to new OSHA regulations during this period is all too easy. Only two standards became effective during this period which both set PELs and supplanted pre-existing OSHA standards. (There was no formal OSHA standard for coke oven emissions prior to the standard set in 1976 and thus no basis in this data for calculating pre-OSHA compliance levels.) OSHA adopted an emergency asbestos standard of 5 fibers per cc. in December 1971, a reduction from 12 fibers. The permanent standard OSHA adopted in November 1972 maintained the 5 fiber PEL until July 1, 1976 when it was lowered to 2 fibers. As the data in Table 21 show, a sharp decline in the percentage of samples exceeding the 5 fiber limit occurred during the 1973 to 1975 period. The 1979 to 1981 period shows a continuation of the reduction in exposures above the PEL, a difference magnified by the fact that the PEL had declined by 60%. If we make the same two period comparison we used above, the percentage of violation samples drops from 12.00% to 5.90%; if we adjust for the change in the PEL (by counting only those post 1979 samples which are more than 3 times the PEL and 1/2 of those that are 2 to 3 times the PEL), the reduction is to 1.86%.

For vinyl chloride, the OSHA standard was a 500 ppm ceiling until April 1, 1974 when an emergency 50 ppm standard was established. the new 1 ppm standard took effect at the start of 1975; however, OSHA agreed to grant employers a year in which they could allow workers not to wear respirators but were not yet required to have engineering controls. The excessive exposures in those situations are apparently recorded under Category 9 in the Table. In light of the mid-period shifts in PELs and the samples in the special category, exposures appear to have dropped substantially. That conclusion is corroborated by the reports that the industry, which in 1974 had average exposures of 5 to 15 ppm for most workers, had achieved general compliance with the 1 ppm limit.

These two cases do not demonstrate what would have happened in the absence of OSHA. We could argue that OSHA chooses to set new standards for precisely those substances for which the evidence of new hazardousness is strongest. In that event, it would be very difficult to ever distinguish the independent effects of OSHA in this sort of test. These tests do not, however, suggest that recommendations alone have had much impact on changing exposures.

237

Uses of the MIS Health Data

This report has described the problems with the health data in the OSHA MIS system and has tried to discover what insights the data can provide. How valid are the results? It is difficult to say. Many of the findings--e.g., about overexposure rate differences among industries--are congruent with prior knowledge, which should give us some confidence that the data tell us something about reality. Of course, the real test of whether you trust a study is whether you accept its findings when they are not congruent with prior expectations. I have tried to specify those cases--e.g., establishment size and the NUMSUBS variable--where I think that the results may partly be artifacts of either the definition of the variable or the vagaries of the inspection system. In yet other cases--e.g., the failure of the union variable to have a negative sign--I can't think of any plausible way to explain away the results. I think that even the results on establishment size provide new knowledge despite the ambiguities in defining "firm performance."

Although some attention has been given to evaluation, the primary focus of this report has been on explaining variations in exposure outcomes rather than reviewing the uses of the data for policymakers. This section addresses the latter question. What are those uses? One is to design a better system for targeting health inspections. A second is to improve OSHA's capabilityto evaluate its own activities. A third is to provide a source of information about the extent of worker exposures to toxic substances, a source that could be used to help establish priorities for standard-setting. Each of these is examined in more detail below. Before begining, however, it's important to note that when we address policy uses, we are less concerned with whether the data meet some abstract level of validity than with whether they are more valid and can do a better job than existing data sources.

Targeting Inspections

The current OSHA procedure for programmed health inspections, as described in CPL 2.25B, involves several components. A group of experts assigned hazard ratings to toxic substances, based on the nature of the health effects. For each industry, these ratings are multiplied times the number of workers exposed to those substances which are found in that industry. This creates an "industry weighted index". The number of workers exposed in each industry is taken from the NIOSH NOH Survey. The Survey has been widely criticized as a misleading source of exposure information. (See, for example, the American Industrial Health Council "Reply" of October 23, 1978 to the estimate that 20% to 38% of all cancers have an occupational etiology.) It counted as exposed anyone who worked in an area where a particular substance was present and made no distinctions about the level of exposure. A second factor--the average size of establishments in that industry--is also considered. This ranking and the ranking of the "industry weighted average" are added together and industries are given priority in order of the combined rank value (lowest first).

This system may represent an improvement over earlier programming methods, but it does seem to have several defects. As several IHs complained to me, the policy tells them that the top priority is to inspect large Dow and DuPont plants. In fact, large chemical plants--in their view--tend to do an excellent job of controlling exposures. Whether that is true is, of course, an empirical question, but the point is that experience with a particular category of plants is likely to be a better guide to finding problems than a formula that is based on the number and type of substances used without regard to the technological processes and the extent of the exposures.

Because of their dissatisfactions with the CPL 2.25B policy, hygienists in Regions 1 and 3 have developed their own targeting plans, basing them primarily on their own regional experience with different industries. Hopefully, OSHA will give serious attention to evaluating the success of these experiments. To be worth evaluating, the Regions must employ a consistent protocol in implementing their programs; otherwise it will not be clear what the "program" is that is being evaluated.

Any formula for targeting inspections could benefit from the judgment and experience of good hygienists; formulae should be supplemented by judgment. But even the best hygienist can benefit from the data that the MIS can provide. A single IH rarely has enough experience to make statistically valid discriminations solely on the basis of his own inspections. It is not certain exactly what variables should be included or what the inspection program's objective is. One goalcould be to maximize the number of workers removed from exposures--with the exposures weighted both for the nature of the hazard and the extent of the overexposure. This exposure data would be drawn from past inspections. In order to take into account constraints on the number of hygienists, the average number of hours would also have to be examined for different categories of inspections. For example, it may take three times as long to inspect a large plant as a small plant. If so, the latter should get priority even if the former has a slightly higher expected number of workers removed from risk. One problem with any targeting program is that it must determine whether its goal is detection or deterrence. Spreading inspections among different industries may increase awareness of OSHA's presence and its rules; however, deterrence seems likely to be more potent in the safety area than in health. The chief reason is the relatively high costs of any particular compliance measures. Firms for whom the expected costs are the crucial issue are not likely to be deterred by the threat of "first-instance" fines. (This is not to deny that some firms make compliance decisions without regard to strict weighing of benefits and costs.) Thus it seems reasonable to base health targeting primarily upon a detection strategy.

Another problem arises in dealing with the increasing number of firms that will already have been inspected. Decisions about whether to reinspect them and, if so, how often may require a somewhat different approach. The current MIS data--because of its incompleteness--is not as reliable as we would like in identifying whether workplaces have been sampled more than once. However, the existing data may still be better than nothing; more importantly, plans to remedy the failure to report should provide better data for future targeting. Here again, the variables of industry and size could probably be used to predict the likelihood of overexposures. However, in these cases, the IH will have had experience in dealing with the plant officials, which will give him a better sense of what to expect. For this reason, long service in one area seems like a desirable trait for an IH, although there may be other considerations that push the other way.

Assessing Current Exposures

One possible use for the data in the MIS is to help OSHA assess the number of workers exposed to different levels of toxic substances. The proposed use here is a very specific one: to help OSHA decide which substances are currently causing the greatest health damage and thus should potentially be the subject of OSHA's limited standard-setting resources. (Of course, the potential costs of regulation, as well as the potential health benefits, should be taken into account in these decisions.) Once OSHA has made a decision to devote major attention to a substance, it commissions economic impact studies which usually generate information about the number of workers exposed and the levels of exposure. But currently OSHA has only one source of information on which to base choices about which hazards are worth serious investigation. That source is the NIOSH National Occupational Health Survey, which is not very useful because it conveys no information about the level of exposures. The surveyor recorded all materials and physical agents each employee group potentially encountered, although he did distinguish part-time from full-time duration of exposures and whether controls were utilized. Because it does provide exposure levels, the MIS data may be more useful.

The obvious drawback of the MIS data is that, unlike the NOH Survey, it was not based on a random sample, many plants are never inspected, and even for those that are, the sample data are often never submitted to the MIS. Despite these problems, there are many industries where the MIS includes sample data for a large, sometimes overwhelming proportion of the plants. Generally, these are industries which are known to have compliance problems (e.g., lead battery plants) or which use highly toxic substances (e.g., asbestos manufacturing). For example, we compared the number of inspections in our lead file for five of the most frequently inspected industries and compared them with the number of plants in those industries listed in the Census of Manufacturers for 1977. Because our data includes inspections from 1972 to 1979 and because many states were subject to Federal OSHA inspections for only part of that time ("state plan" states did not submit sample data to the OSHA MIS), we limited the plants to those 21 states which had continuously been subject to Federal OSHA or had been outside for less than a year. The comparision is shown in Table 21. For most of the plants the MIS does have sample data. In several cases there are more plants reported in the MIS than in the Census of Manufacturers. Some of these weredue to multiple inspections of the same plant, which are reported in the Table for the two industries which we checked. Others are undoubtedly due to the fact that the Census number is an estimate for a single point in time, while over this period some turnover in plants occurred. Finally, there is probably some misreporting of the SIC industry codes. The point, however, is that for these industries the problems of non-randomness and incompleteness co-exist with a large amount of data about exposures. For policymakers, the question is whether this exposure data could add insights beyond what the NOH Survey provides.

One way to get a better sense of the MIS's contribution would be to systematically compare the exposures it reports with the exposure estimates in the economic impact analyses. Would the MIS data have allowed a better prediction than the NOHS of the figures found in the more thorough industry study? It might also turn out that if the NOHS data are adjusted in certain ways, they may provide good estimates (e.g., as a hypothetical example, perhaps the number or workers exposed above the PEL is usually found to be 30% of the workers with "full-time" exposure in the NOH Survey).

The industries for which we have extensive exposure data will tend to be industries with hazards that are well-recognized. Nevertheless, the frequency with which substances are sampled by OSHA may be a good indicator of the relative frequency that they actually appear in workplaces; and the exposure levels that are found may be good indicators of the distribution of exposures. These questions deserve further study. But even for well-known hazards, OSHA needs more information. Should OSHA proceed with a new, lower PEL for asbestos? The answer depends partly upon the number of people exposed to different levels of asbestos now. Does such a change deserve priority over the long-considered change in the PEL for chromium, another carcinogen. With good exposure data, we could estimate the number of cancers that would be prevented by proposed reductions in either PEL. (Of course, this would require applying estimates of dose-response curves to the exposure data.)

Evaluating Exposure Trends and OSHA's Impact

We have taken some pains to point out the difficulties in using the MIS data for evaluation purposes. It remains probable that the data would still provide a useful indicator for very large changes and for changes in particular industries that are heavily inspected. Plans are now underway at OSHA to have the Salt Lake City Lab submit the sample data directly to the MIS. With complete reporting, it will be possible to develop reliable worksite-specific histories. Indeed, for some current purposes, it may be worthwhile to obtain the inspection reports and copy the sample data that were not submitted to the MIS. For example, an evaluation of the current health targeting experiments in

Regions 1 and 3 will be badly compromised if reporting is incomplete; obtaining any missing data manually would be in order. Using the MIS to assess health enforcement projects would require rigorous attempts to ensure that similar sampling protocols were used at all sites.

The uses discussed above pertain to OSHA's ability to assess different enforcement strategies. It would be enlightening to have data that really did allow us to track exposure trends. It would be enlightening, but would it be useful? The Bureau of Labor Statistics Survey of accidents and illnesses has been widely criticized for failing to collect useful information, for safety as well as health. Before endorsing a regular random sampling of large numbers of exposures at hundreds of workplaces each year, we should be clear about exactly what we would learn and how we would use the information. It may turn out that conducting 500 such inspections a year is valuable. I believe that such a survey should be conducted at least once, primarily as a tool for assessing the validity of the MIS data. OSHA already has a system that collects health data from 5,000 to 10,000 inspections a year. Rather than establishing a totally independent program, efforts should be directed at making the MIS more useful.

One method to reduce the added costs of such a random survey would be to formally incorporate it in OSHA's general schedule inspection program, with a focus on those industries known to have exposure problems. It might not require very drastic changes in the current high hazard targeting program to achievethis goal. (Problems stemming from the Supreme Court's Barlow decision would have to beaddressed in designing this program.) If NIOSH conducted the sampling, extra manpower would be required but all of the paperwork associated with enforcement could be foregone.

If such a survey were to find that the MIS is extremely misleading and thus was not at all useful for targeting inspections or for estimating the rough magnitude of worker exposures, then serious attention should be devoted to a regular, extensive random survey.

236

TABLE 1

OSHA INSPECTIONS BY TYPE AND FISCAL YEAR

a. Total Inspections

Fiscal year	General schedule	Accident	Follow-up	Complaint	TOTAL
1973	32,223	2,456	7,135	6,623	48,437
Percent	(66.5)	(5.1)	(14.7)	(13.7)	(100.0)
1974	56,330	2,216	12,114	6,409	77,069
Percent	(73.1)	(2.9)	(15.7)	(8.3)	(100.0)
1975	56,547	1,884	15,375	7,139	80,945
Percent	(69.9)	(2.3)	(19.0)	(8.8)	(100.0)
1976	63,381	1,914	15,866	9,160	90,321
Percent	(70.2)	(2.1)	(17.6)	(10.1)	(100.0)
TQ*	9,828	489	3,395	4,689	18,401
Percent	(53.4)	(2.7)	(18.4)	(25.5)	(100.0)
1977	24,847	1,777	13,942	19,270	59,836
Percent	(41.5)	(3.0)	(23.3)	(32.2)	(100.0)
1978	20,220	2,064	13,424	21,485	57,193
Percent	(35.3)	(3.6)	(23.5)	(37.6)	(100.0)
1979	23,755	2,301	11,696	20,158	57,910
Percent	(41.0)	(4.0)	(20.2)	(34.8)	(100.0)

*Transition quarter required by change in fiscal year.

SOURCE: Bureau of National Affairs, *Occupational Safety and Health Reporter*, March 27, 1980: 1013

b. Health Inspections

Fiscal Year	General Schedule	Complaint	Follow-up	Accident	Total
1973	2181	622	364	17	3184
1974	2766	757	408	22	3953
1975	3677	1194	623	25	5519
1976	4453	2114	992	38	7597
TQ 76	568	841	324	8	1741
1977	2963	5117	1885	47	9112
1978	1773	6638	2154	92	10657
1979	2138	6783	2046	110	11077
1980	3391	6120	2179	149	11839
1981	3685	5576	1316	181	10758
1982	5465	3007	595	147	9214

Table 2

Number of Inspections by Inspection Type: Selected Substances by Year

	Lead				Silica			
Year	General Schedule	Complaint	Follow up	Total	General Schedule	Complaint	Follow up	Total
1973	138	69	18	225	237	56	7	350
1974	157	59	31	247	211	48	19	278
1975	244	95	33	372	282	74	32	388
1976	208	201	40	449	112	118	38	268
1977	122	269	82	473	51	186	54	291
1978	98	376	66	540	67	199	50	316
1979*	32	116	21	169	17	53	12	82
	999	1185	291	2475	1027	734	212	1973

	Asbestos				Trichloroethylene			
Year								
1973	102	20	10	132	11	19	2	32
1974	106	39	11	158	23	24	4	51
1975	181	37	12	230	39	30	2	71
1976	80	108	18	206	41	78	9	128
1977	86	208	27	321	23	110	5	138
1978	81	327	10	418	20	70	20	110
1979*	27	115	4	146	7	36	7	50
	665	854	92	1611	164	367	49	580

* For only part of the year

TABLE 3

Percentage of Inspections with Violations for Overexposures - By Inspection Type Selected Substances

	Inspection Type			
Lead	C	G	F	ALL
1973	7%	13%	0%	10%
1974	3%	8%	10%	7%
1975	13%	16%	9%	14%
1976	13%	19%	20%	17%
1977	22%	16%	21%	20%
1978	18%	15%	17%	17%
1979°	21%	28%	10%	21%

	Inspection Type			
Silica	C	G	F	ALL
1973	18%	23%	14%	22%
1974	17%	22%	22%	21%
1975	31%	28%	9%	27%
1976	31%	30%	29%	31%
1977	28%	25%	19%	26%
1978	25%	21%	12%	22%
1979°	34%	12%	33%	29%

	Inspection Type			
Asbestos	C	G	F	ALL
1973	5%	6%	10%	6%
1974	11%	15%	0%	11%
1975	16%	13%	17%	12%
1976	21%	16%	17%	16%
1977	8%	9%	4%	7%
1978	13%	7%	0%	10%
1979°	11%	13%	0%	10%

	Inspection Type			
Trichlorethylene	C	G	F	ALL
1973	5%	0%	0%	3%
1974	21%	4%	0%	12%
1975	7%	15%	0%	11%
1976	9%	7%	11%	9%
1977	6%	0%	0%	5%
1978	9%	5%	5%	7%
1979°	3%	0%	0%	2%

° Only part of year

Table 4

The Percentage of Inspections Finding Overexposed Workers, by Year and the Percentage of Those Which Led to Citations for Overexposures

Year	Lead		Silica	
	% of Inspections Finding Overexposures	% of Overexposures Leading to Citations	% of Inspections Finding OverExposures	% of Overexposures Leading to Citations.
1972*	--	--	~~85% (N=13)~~	~~39%~~
1973	35%	29%	55 (N=350)	
1974	31%	23	52	40
1975	27	52	46	59
1976	29	59	46	67
1977	33	61	47	55
1978	31	55	40	55
1979*	30	70	48	60

Year	Asbestos		Trichloroethylene	
1972	--	--	--	--
1973	27%	22%	34%	9%
1974	23	48	24	50
1975	18	67	13	85
1976	18	89	18	50
1977	10	70	14	36
1978	14	71	21	33
1979*	12	83	7	29

Notes: *For only part of the year. Column 2 is the number of inspections citing violations for overexposures of that substance divided by the number of inspections finding overexposures of that substance. (ANYCIT divided by OVEREX)

TABLE 5

CHANGES IN THE SUBMISSION OF HEALTH TEST SAMPLES TO THE OSHA MIS OVER TIME: THERE WAS LESS COMPLETE REPORTING IN LATER YEARS

(1) Year	(2) No. of Health Inspections Reported on OSHA 1s	(3) No. of Health Inspections with Test Samples in the MIS	(4) 3/2	
1972	1274	93	7.3%	49.6%
1973	3733	2390	64.0	
1974	4370	3175	72.7	
1975	6688	4312	64.5	
1976	7740	4539	58.6	
1977	9881	4993	50.5	
1978	10649	5477	51.4	
1979*	2974	1486	50.0	

*Only part of year

Table 8
Mean Values of the Dependent Variables
(Standard deviations in parentheses)

All Inspections

	Asbestos	Lead	Silica	Trichlorethylene
N	1617	2500	1986	606
ANYCIT	.1045 (.3060)	.1608 (.3674)	.2487 (.4324)	.0743 (.2624)
WSEVPER	.6971 (.5783)	.9747 (.9748)	1.2395 (1.1273)	.6839 (.5181)
SEVPER	.1303 (.3211)	.2162 (.3722)	.3408 (.4219)	.1240 (.3012)
SEVEMP	1.7310 (9.5733)	5.5332 (48.3189)	9.0206 (53.2744)	1.2591 (9.0166)
OVEREX	.1602 (.3669)	.3108 (.4629)	.4799 (.4997)	.1766 (.3816)

General Schedule Inspections

N	674	1016	1038	164
ANYCIT	.1024 (.3034)	.1575 (.3644)	.2468 (.4324)	.0671 (.2509)
WSEVPER	.7155 (.6130)	.9626 (.9483)	1.2637 (1.1236)	.7145 (.5906)
SEVPER	.1381 (.3275)	.2128 (.3671)	.3557 (.4255)	.1407 (.3249)
SEVEMP	2.0593 (11.9486)	4.750 (34.7238)	9.7177 (58.6035)	.8841 (3.1221)
OVEREX	.1721 (.3778)	.3091 (.4623)	.4952 (.5002)	.1768 (.3827)

Complaint Inspections

N	851	1191	736	409
ANYCIT	.1093 (.3122)	.1654 (.3717)	.2677 (.4430)	.0807 (.2727)
WSEVPER	.6642 (.5220)	.9392 (.9829)	1.2058 (1.1374)	.6741 (.5007)
SEVPER	.1141 (.3065)	.1922 (.3613)	.3204 (.4211)	.1150 (.2909)
SEVEMP	1.2961 (6.1857)	4.9580 (59.7063)	7.5299 (47.1828)	1.4523 (10.7825)
OVEREX	.1363 (.3433)	.2737 (.4461)	.4443 (.4972)	.1663 (.3728)

TABLE 9

REGRESSION SUMMARY STATISTICS

	OVEREX	ANYCIT	SEVPER	SEVEMP	WSEVPER
Trichloroethylene					
All Inspections					
R^2	.090	.070	.096	.068	.100
F	1.839***	1.391*	1.968***	1.350*	2.064***
General Schedule					
R^2	.183	.144	.184	.146	.249
F	0.913	0.850	1.136	0.863	1.667**
Complaint					
R^2	.101				.092
F	1.524**				1.382*
Asbestos					
All Inspections					
R^2	.072	.055	.054	.031	.060
F	2.891****	2.161****	2.145****	1.191	2.381****
General Schedule					
R^2	.105	.080	.084	.066	.083
F	1.852***	1.373*	1.454**	1.114	1.428**
Complaint					
R^2	.073				.078
F	1.626***				1.754***
Silica					
All Inspections					
R^2	.112	.038	.073	.067	.063
F	5.846****	1.818***	3.647****	3.312****	3.093****
General Schedule					
R^2	.146	.057	.113	.121	.095
F	4.254***	1.507	3.171****	3.426****	2.631****
Complaint					
R^2	.134				.118
F	2.767****				2.389***
Lead					
All Inspections					
R^2	.199		.139		.118
F	13.577****		8.770****		6.861****
General Schedule					
R^2	.223	.076	.139	.154	.110
F	6.498****	1.854***	3.659****	4.129****	2.794****
Complaint					
R^2	.224				.144
F	7.679****				4.475****

* significant at .10
** significant at .05
*** significant at .01
**** significant at .001

TABLE 10

RESULTS: REGRESSION ON "OVEREX" FOR ALL ASBESTOS INSPECTIONS

Variable	Coefficient	Standard error	Beta	F statistic
[illegible]	-0.6[illegible]	[illegible]	[illegible]	[illegible]
INTYPE[illegible]	0.1246[illegible]	[illegible]	[illegible]	[illegible]
INTYPE[illegible]	0.8[illegible]	[illegible]	[illegible]	[illegible]
NUMSUBS	-0.7956[illegible]	[illegible]	0.0[illegible]	5.104
[illegible]	[illegible]	[illegible]	0.07[illegible]	[illegible]
Y74	-0.3899392E-0[illegible]	-0.00294	0.04231	0.098
Y75	-0.3045597E-0[illegible]	-0.02901	0.04161	0.536
Y76	-0.1660596E-0[illegible]	-0.01510	0.04305	0.143
Y77	[illegible]	[illegible]	[illegible]	[illegible]
Y78	-0.3231536E-0[illegible]	-0.03069	0.04263	0.576
Y79	-0.1193914E-0[illegible]	-0.02652	0.05029	0.455
SIZE20	0.3247[illegible]	0.03312	0.02985	2.106
SIZE50	[illegible]	0.00226	0.05330	[illegible]
SIZE100	0.2942516E-0[illegible]	0.03310	0.03184	0.054
SIZE250	0.5517179E-0[illegible]	0.04605	0.03679	2.249
SIZE500	0.1217108E-0[illegible]	0.00971	0.03068	0.099
SIZE1000	[illegible]	-0.01020	[illegible]	[illegible]
SIZE2500	-0.4023847E-0[illegible]	-0.03307	0.05176	0.605
SIC3292	0.2144452	0.15267	0.04387	24.675
SIC3714	-0.6302230E-01	-0.02695	0.07548	0.636
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SIC1799	0.1155106	0.04951	0.06252	3.416
SIC2952	0.1481630	0.06041	0.06493	5.209
SIC1520	0.107[illegible]	0.03950	0.07132	2.266
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SIC7539	-0.66[illegible]E-0[illegible]	-0.02269	0.06933	0.7[illegible]
SICCON	0.5[illegible]E-0[illegible]	0.04514	0.03052	2.[illegible]
SICNOND	0.1[illegible]	0.09440	0.042[illegible]	10.[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SICRUB	0.5746736E-01	0.03167	0.04972	1.336
OTHE432	0.1550966	0.10790	0.06269	16.032
SICPRIM	0.1397012	0.06607	0.04703	8.026
SICFAB	[illegible]	[illegible]	[illegible]	[illegible]
SICMACH	0.1[illegible]984	0.10806	0.04658	1[illegible]
SICELEC	0.2508462	0.06275	0.04090	[illegible]
SICTRAN	0.1[illegible]	0.03502	0.05884	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
PREDICTU	-0.7786964E-02	-0.01065	0.02030	0.147
PNSEVPER	0.8816302E-06	0.00003	0.00073	0.000
PCITTV	0.4531606E-01	0.01731	0.06086	0.431
[illegible]	-0.[illegible]	-0.00380	[illegible]	[illegible]
KPRIOR	-0.5321003E-01	-0.03729	0.04078	1.703
(CONSTANT)	0.1561679			

Reproduced from
best available copy.

R^2=.07162 Standard error=.35818 F=2.89106

Table 11

TESTEMP (number of employees tested) BY SIZE CLASS OF WORKPLACE

	1-19	20-49	50-99	100-249	250-499	500-999	1000-2499	2500+	All
Lead									
Mean	6.8	14.1	20.6	36.6	107.8	30.6	61.9	23.0	37.7
S.D.*	7.1	20.2	33.3	83.3	582.8	58.7	226.1	19.2	236.0
N. of cases	97	115	126	206	116	54	32	30	777
Asbestos									
Mean	4.5	10.7	16.8	19.0	14.4	24.3	10.0	19.0	13.8
S.D.	3.2	14.5	21.0	31.9	22.3	43.1	11.0	16.5	23.9
N of cases	48	48	30	53	37	23	14	6	259
Silica									
Mean	6.4	8.9	12.2	28.5	26.4	58.6	170.0	136.4	38.6
S.D.	10.9	8.0	16.0	58.8	44.3	110.2	572.2	279.6	176.1
N of cases	57	108	123	157	103	59	49	36	692
Trichloroethylene									
Mean	4.6	13.9	5.3	14.8	5.7	11.0	17.4	74.0	13.0
S.D.	4.1	18.5	4.6	35.5	4.2	13.1	22.5	109.5	28.7
N of cases	8	16	14	32	12	15	7	3	107

*Standard deviation

TABLE 12

DIFFERENCES AMONG INDUSTRIES IN THE WEIGHTED SEVERITY OF EXPOSURES (WSEVPER); ALL INSPECTIONS

Industry	ASBESTOS	SILICA	TCE	LEAD
SICCON (SIC<2000)	+.078	+.208		+.621***
SICNOND	+.167**	-.433**		-.114
SICCHEM (28, Chemicals)		-.248		
OTHCHEM (Other 28)	+.183***			+.346***
SICRUB (30, Rubber)	+.124	-.202	-.138	
OTHPRINT (27, Printing)				-.356**
SICSTONE (32, Stone, etc.)				-.098
OTHER 32	+.213***	-.039		
SICPRIM (33, Primary metal)	+.271***		-.062	
OTHER 33		-.400**		
OTHPRIM				-.170*
SICFAB (34, Fabricated met.)	+.222***	+.004	+.273***	
OTHFAB				-.187*
SICMACH (35, Machinery)	+.240***	-.332*	+.043	
OTHMACH				-.010
SICELEC (36, Electrical)	+.110	-.212		
OTHER 36			+.110	
OTHELEC				-.189**
SICTRAN (37, Transportation)		+.046	+.117	+.154*
OTHER 37	+.181*			
SICDUR	+.084	-.392*		-.033
1520 Residential const.	+.215*			
1799 Special trades const.	+.195**			
2711 Newpapers				-.278
2751 Print, letterpress				-.390**
2851 Paint products	+.162*			+.052
2952 Asphalt products	+.271***			
3272 Concrete products		-.349		
3281 Cutstone products		+.196		
3290	+.054			
3292 Asbestos products	+.193***			
3312 Blast furnaces		-.229		
3321 Grayiron foundry		+.106		+.076
3322 Malleable iron foundry		+.089		
3324 Steel invest. foundry		+.213		
3332 Primary lead				+.662**
3341 Secondary nonferrous				+.430***
3356 Nonferrous rolling				-.001
3361 Aluminum foundries		-.433**		
3362 Brass foundries		-.339*		
3369 Nonferrous foundries		-.350		
3411 Metal cans				-.356**
3441 Fabricated metal				-.188
3443 Boiler shops				-.170
3531 Const. machinery				+.496***
3662 Radio and TV mfg.				-.364**
3679 Elec. components			+.016	-.265*
3691 Storage batteries				+.294***
3714 Auto parts	-.143			
7539 Auto repair	-.083			

TABLE 13

REGRESSION ON OVEREX FOR LEAD GENERAL SCHEDULE INSPECTIONS

```
LEAD.LOG11                                     22-MAR-1982 15:47:35.09
BASIC PROGRAM FOR ALL SUBS                                                                PAGE 30
                    coefficient          standard error                             "F"
METRO             0.1129222E-01          0.01081              0.03137              0.131
PRIORIN           0.2958168E-01          0.03196              0.03514              0.708
NUMSUBS          -0.5591321E-02         -0.06438              0.00492              3.808
SEVSUBS           0.7493066E-01          0.16327              0.01390             26.772
Y74              -0.[illegible]E-01     -0.02822              0.04859              0.610
Y75              -0.[illegible]E-01     -0.05320              0.05037              1.306
Y76              -0.4003050E-01         -0.04022              0.05345              0.742
Y77              -0.5023550E-01         -0.03509              0.05928              0.732
Y78              -0.[illegible]E-01      0.0[illegible]       0.06[illegible]30    0.128
Y79               0.1982[illegible]E-02  0.00598              0.08993              0.03[illegible]
SIZE20            0.9198229E-02          0.00726              0.04431              0.043
SIZE50            0.1563522E-02          0.00622              0.04863              0.001
SIZE100           0.[illegible]E-01      0.02062              0.04714              2.926
SIZE250           0.1000532              0.0[illegible]082    0.05449              3.933
SIZE500           0.7080840E-01          0.03829              0.06666              1.199
SIZE1000          0.3496261E-01          0.01916              0.06582              0.282
PREDCIV          -0.[illegible]E-01      0.03300              0.07761              1.125
SICCON           -0.5433[illegible]E-01  0.01822              0.09764              0.310
NONDUR           -0.1673095             -0.07528              0.05061              6.308
SIC2711          -0.1465124             -0.06290              0.10903              1.808
SIC2751          -0.15[illegible]695    -0.04[illegible]      0.10660              2.252
OTHPRINT         -0.20[illegible]62     -0.06[illegible]00    0.08609              5.019
SIC2851          -0.3711403E-01         -0.01006              0.11672              0.101
OTHCHEM           0.1157[illegible]      0.05572              0.07510              2.315
SIC3069           0.4050397              0.27326              0.06085             46.603
SIC3262           0.2536724              0.11977              0.07894             10.309
SIC3341           0.2098764              0.13460              0.07889             13.743
SIC3351          -0.1371109             -0.04019              0.11030              1.543
SIC3352           0.3210612              0.16038              0.11662             20.013
SIC3356          -0.4705402E-01         -0.01228              0.11901              0.156
OTHPRIM           0.1670532E-01          0.00748              0.07652              0.039
SIC3531           0.2888079              0.35247              0.13693              3.629
OTHMACH          -0.[illegible]E-01     -0.02924              0.02455              0.002
SIC3662          -0.2247087             -0.04548              0.16914              2.262
SIC3679          -0.2075988             -0.05762              0.15362              3.318
OTHELEC          -0.[illegible]E-01     -0.03[illegible]6     0.07220              0.673
SIC[illegible]    0.[illegible]E-01      0.00[illegible]22    0.07606              0.042
SIC3421          -0.2777906             -0.08351              0.10766              6.658
SIC3442          -0.1007157             -0.02355              0.13108              0.590
SIC3443           0.2252591              0.05266              0.13252              2.889
OTHFAB           -0.5080399E-01         -0.03026              0.06711              0.573
SICSTONE          0.3979157E-01          0.01526              0.08898              0.200
SICDUR           -0.3384490E-01         -0.01538              0.07907              0.183
(CONSTANT)        0.2162164

ALL VARIABLES ARE IN THE EQUATION

STATISTICS WHICH CANNOT BE COMPUTED ARE PRINTED AS ALL NINES.
```

TABLE [illegible]

REGRESSION ON OVEREX FOR LEAD COMPLAINT INSPECTIONS

```
LEAD.LOG[illegible]                                  22-MAR-1982 17:45:41.80
BASIC PROGRAM FOR ALL SUBS                                                         F
                 coefficient          standard error
METRO          [illegible]            [illegible]              0.02751         6.827
PRIORIN       -0.1646500E-01         -0.01827                  0.02770         0.351
NUMSUBS       -0.1971717E-01         -0.15906                  0.00360        30.067
SEVSUBS        0.9444543E-01          0.22990                  0.03165        65.673
[illegible]    0.4490534E-01          [illegible]              [illegible]     [illegible]
V75            0.6201200E-01          0.04983                  0.05407         1.558
V76            0.7178615E-01          0.06030                  0.05815         1.524
V77            0.1462201              0.13525                  0.05760         6.270
V78            0.1223306              0.13294                  0.05605         [illegible]
V79            0.8466823E-01          0.0553C                  0.06445         1.726
SIZE20         0.7007416E-01          0.05244                  0.04915         2.033
SIZE50         0.5665569E-01          0.04623                  0.04807         1.389
SIZE100        0.2227570E-01          0.06611                  0.06381         2.285
SIZE250        0.2762716E-01          0.02239                  0.05197         0.283
SIZE500        0.7426947E-01          0.05069                  0.05682         1.709
SIZEBIG        0.3339094E-01          0.02561                  0.05590         0.357
PREDICTM       0.2067631E-01          0.02267                  0.02792         0.548
SICCON         0.1629564              0.05239                  0.08782         3.443
NONDUR         0.5469197E-03          0.00022                  0.07340         0.000
SIC2711       -0.1557737             -0.03896                  0.11175         1.943
SIC2751       -0.1232381             -0.02822                  0.11684         [illegible]
OTHPRINT      -0.7650683E-01         -0.02093                  0.10122         0.571
SIC2851        0.1016646              0.02543                  0.11051         0.846
OTHCHEM        0.1449061              0.05855                  0.07293         3.948
SIC3691        0.5609906              0.22141                  0.07562        55.321
SIC3362        0.3066653              0.09975                  0.08779        12.027
SIC3341        0.4288259              0.16687                  0.07605        31.792
SIC3321        0.3020184E-01          0.00803                  0.10692         0.080
SIC33[illegible]   0.4283276          0.09098                  0.12708        11.126
SIC3355        0.2623012              0.05368                  0.13225         3.934
OTHPRIM       -0.9251629E-01         -0.05226                  0.05721         2.641
SIC3531        0.9598968E-01          0.02554                  0.10501         0.836
OTHMACH        0.1752000E-01          0.01114                  0.05324         0.108
SIC3662       -0.1849102             -0.05584                  0.09348         3.912
SIC3679       -0.1603926             -0.05991                  0.07825         4.202
OTHELEC       -0.9571423E-01         -0.06190                  0.05319         3.238
SICTRAN        0.9160256E-01          0.06138                  0.05324         2.960
SIC3411       -0.2682927E-01         -0.00828                  0.09226         0.025
SIC3461       -0.8298605E-01         -0.02143                  0.10735         0.598
SIC3443       -0.2443029             -0.07540                  0.09175         7.050
OTHFAB        -0.5308954E-01         -0.03567                  0.05346         0.987
SICSTONE      -0.9275011E-02         -0.00384                  0.07174         0.017
SICDUP        -0.1669609             -0.07927                  0.06459         6.681
(CONSTANT)     0.1856282

F-LEVEL OR TOLERANCE-LEVEL INSUFFICIENT FOR FURTHER COMPUTATION

STATISTICS WHICH CANNOT BE COMPUTED ARE PRINTED AS ALL NINES.
```

Reproduced from best available copy.

Table 17

HAVE EXPOSURES DECLINED OVER TIME?
THE COEFFICIENTS FOR "YEARS" IN THE GENERAL SCHEDULE REGRESSIONS

	TRICHLOROETHYLENE					ASBESTOS				
	OVEREX	ANYCIT	SEVPER	WSEVPER	SEVEMP	OVEREX	ANYCIT	SEVPER	WSEVPER	SEVEMP
1974	-.146	-.010	-.116	+.014	+.275	-.029	+.065**	-.030	-.026	+1.52
1975	-.397***	+.072	-.272**	-.342	-.591	-.016	+.093***	-.004	-.119**	+1.37
1976	-.264*	+.112	-.209*	-.167	+.185	-.056	+.139***	-.040	-.059	-0.82
1977	-.523***	-.044	-.380***	-.421	-1.22	-.076	+.055*	-.040	-.159***	+0.87
1978	-.304*	-.009	-.257**	-.317	+1.59	-.041	+.083**	-.024	-.090*	-0.28
1979	-.493***	-.042	-.366**	-.429	-1.50	+.115	+.092**	+.078	-.064	+1.16

	SILICA					LEAD				
1974	-.009	+.004	-.007	+.036	-5.83	-.038	-.076**	-.017	+.012	+2.04
1975	-.010	+.094**	+.057*	+.182*	-8.02*	-.057	-.014	-.025	-.047	+7.46**
1976	+.034	+.123**	+.079*	+.448***	-10.8	-.046	+.022	-.026	-.038	+12.49***
1977	-.036	+.079	-.009	+.176	-18.8**	-.051	-.004	-.033	-.124	+7.40*
1978	-.076	+.042	-.022	+.113	-5.75	+.023	-.012	-.018	-.024	+9.97**
1979	-.262**	-.054	-.217**	-.306	-14.9	+.015	+.102	+.036	+.074	+7.17

Note: These coefficients are calculate relative to the 1973 inspection findings. Thus, for example, holding size of plant, industry, and other variables constant, OVEREX (the propestion of inspections finding at least one worker exposed above the PEL) was 0.146 lower in 1974 than it was in 1973.

* Significant at the .10 level, 1 tailed test
** Significant at the .05 level, 1 tailed test
*** Significant at the .01 level, 1 tailed test.

TABLE 18

Have Exposures Changed Over the Years?: Complaint Inspections

	TRICHLOROETHYLENE		ASBESTOS		SILICA		LEAD	
Year	OVEREX	WSEVPER	OVEREX	WSEVPER	OVEREX	WSEVPER	OVEREX	WSEVPER
1974	-.133	-.092	-.006	+.134	-.062	-.344*	+.041	+.143
1975	-.230**	-.189	-.055	-.098	-.042	-.060	+.082	+.043
1976	-.141*	-.082	+.004	+.045	-.102	-.315*	+.072	+.026
1977	-.175**	-.161	-.082	-.078	-.043	-.178	+.144***	+.080
1978	-.111	-.075	-.035	-.004	-.112	-.400**	+.128***	+.094
1979	-.299***	-.300**	-.063	-.011	-.052	-.313*	+.085*	+.158

Note: These coefficients are calculated relative to the 1973 inspection findings. Thus, for example, for trichloroethylene, OVEREX (the percentage of inspections finding at least one worker overexposed to that substance) was lower by .133 in 1974, holding other variables constant.

* significant at the .10 level, 1 tailed test
** significant at the .05 level, 1 tailed test
*** significant at the .01 level, 1 tailed test

Table 19

DO EXPOSURES DECLINE WHEN RECOMMENDED EXPOSURE LIMITS ARE REDUCED?

Group 1: No Change in Recommended Exposures Substance (code)	Proportion of Samples Exceeding PEL in Period 1	Proportion of Samples Exceeding PEL in Period 2	Change in proportion/ % change	Change in Recommendation	# of Samples/ Inspections Period 1	
					1	2
Acetone(0400)	.1554	.0112	-.1442/93%	None	1168/145	205/148
Cobalt(0720)	.0142	.0504	-.0362/255	None	141/24	119/47
Ethyl Acetate(1040)	.1242	.0000	.1242/100	None	338/49	175/62
Ethyl Alcohol(1060)	.1825	.0000	.1825/100	None	219/34	63/48
Hydrogen chloride(1430)	.1806	.1059	.0747/41	None	288/71	104/69
Manganese(1620)	.0705	.0265	.0440/59	None	779/165	657/190
Selenium(2230)	.0000	.0666	-.0666/und.	None	53/15	60/14
Group Average	.1039	.0369	.0670			
Group 2: Change in Recommended Exposures						
Hydrogen fluoride(1460)	.0370	.0266	.0104/28%	8ppm 8hr. TWA to 10 ppm C/10 min.	81/16	75/32
Methyl chloroform(1720)	.0548	.0228	.0320/58	50ppm C to 2ppm C	693/109	143/155
Perchloroethylene(2020)	.2614	.1814	.0810/31	100ppm TWA to 50ppm	329/77	112/108
Sodium hydroxide(2260)	.1458	.0101	.1357/74	2mg TWA to 2mg C	144/41	98/58
Styrene(2290)	.2254	.1066	.1188/53	100ppm TWA to 50 ppm TWA	2666/226	356/109
Sulfur dioxide(2290)	.2999	.1874	.1125/38	5ppm 8hr. TWA to 0.5ppm 10 hr TWA	1087/153	65/23
Group Average	.1707	.0890	.0817			

Table 20

CHANGES IN EXPOSURES AFTER NEW OSHA STANDARDS: ASBESTOS AND VC

a. Asbestos

1/73 thru 6/74		7/74 thru 6/75		6/75 thru 12/75		4/79 thru 7/21/81	
#Insp w. OV-EREX/ #Insp	#Samples OVEREX/ #Samples	#Insp w. OV-EREX/ #Insp	#Samples w. OVEREX/ #Samples	#Insp w. OV-EREX/ #Insp	#Samples w. OVEREX/ #Samples		#Samples w. OVEREX/ #Samples
43/217	394/1912	44/207	374/1517	19/111	103/1026		76/1288
# of Samples:							
1-2 times PEL: 205			289		64		45
2-3 times PEL: 99			50		3		14
>3 times PEL: 90			35		36		17

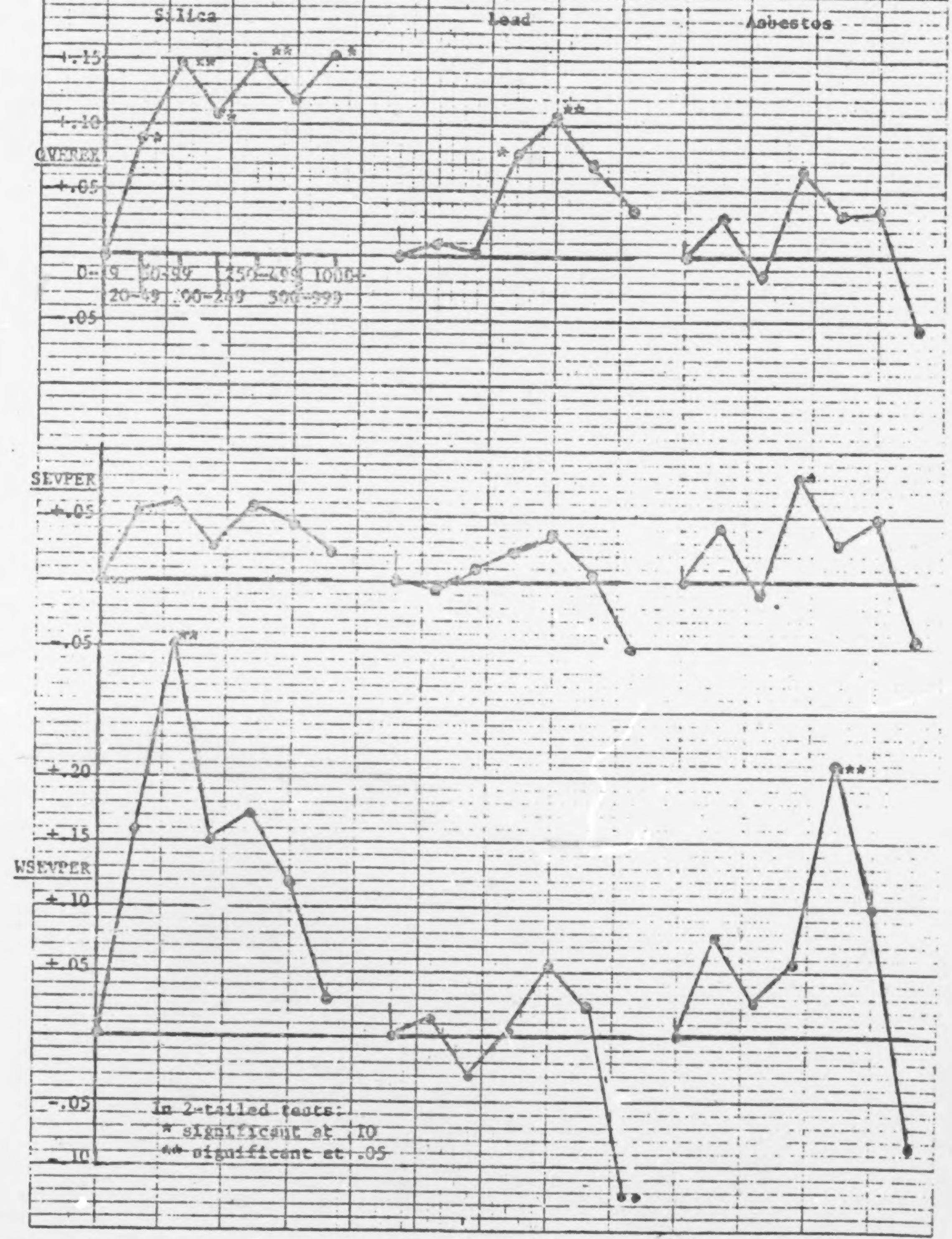
b. Vinyl chloride

8/152	22/622	39/514	531/1931	5/120	96/945		27/148
1-2	6		36		12		10
2-3	0		15		1		1
>3	16		83		13		16
Category	9		597		30		

Note: See text for explanation.

FIGURE 1

THE EFFECTS OF ESTABLISHMENT SIZE ON OVEREXPOSURES: GS INSPECTIONS



10 Squares to the Inch

TABLE 21

A Comparison of the Number of Inspections for Lead in Certain Industries with the Number of Plants in Those Industries According to the 1977 *Census of Manufacturers*

	OSHA MIS Inspections		Census of Manfuacturers	
	Total	Plants> 20	Total	Plants> 20
SIC 3332 primary lead	26	21	5	5
SIC 3341 secondary non-ferrous	68	60	164	74
SIC 3356 non-ferrous rolling	16	12	52	27
SIC 3691 battery manu.	115	94	75	53
SIC 3711 auto manu.	32	32	86	35

Notes: For SIC 3332 and SIC 3691, the MIS file was reviewed to identify the number of different plants covered by those inspections. The numbers were 18 and 89, respectively. These should be compared with the totals for the *Census*. For both the MIS and the *Census* only the 21 states which had been continuously or almost continuously subject to OSHA inspections from 1972 through 1979 were included. For further discussion of these figures, see the text.

Historical Perspective: The Evolution of the Definition of Certain Work-Related Illnesses

Submitted to: Office of Technology Assessment
Contract No.: 333-6940-0
July 29, 1983

Dr. Jacqueline Corn
Assistant Professor
History of Public Health
Department of Environmental Health Sciences
The Johns Hopkins University
School of Hygiene and Public Health
615 North Wolfe Street
Baltimore, Maryland 21205
(301) 955-2609

I. INTRODUCTION AND BACKGROUND

Concepts of health risk associated with occupation have undergone profound change. It is possible to trace observations of the relationship between work and disease back to antiquity when work in mining, metalurgy, pottery making, glass making and the utilization of dyes and ceramic glazes could and did produce sickness. In the past, observations of the relationship between occupation and illness were severely limited by lack of knowledge, small numbers of workers at risk and societal acceptance of work induced illness. The benefits of work, when contrasted with the risks, outweighed the known hazards. It took centuries to replace the belief that disease is an acceptable and unavoidable by-product of work with the idea that prevention and control of hazards on the job can minimize or even eliminate risk. Indeed, dangerous and unhealthy work conditions, once accepted as necessary outgrowth of rapid industrial expansion, are no longer accepted as such.

The growth of technology and its by-product, an urban industrial society, characterized by concentration of industry and large population densities created harsh conditions of labor. The new technologies, new processes and rapid industrialization resulted in an inordinate number of exposures to occupational health hazards in mines and factories. Under such conditions the association between occupation and health was clear. The obstacles to controlling hazards included lack of public concern for workers' health coupled with a lack of knowledge and ineffective action.

In twentieth century America reform depended upon a number of factors. Occupational disease had to be recognized as a problem and protection of worker health included as a public priority. Hazards needed definition and the relation between specific agents in the work environment to disease endpoints needed to be understood. Meager social legislation existed in the first decades of the twentieth century, a period dominated by the philosophy of Social Darwinism and a business ethic of competitiveness. Scientific and technological advances were needed to redefine definitions of disease and to facilitate identification of workplace hazards. At the same time a societal decision to act to control occupational disease was also imperative.

During the progressive period impetus for change came from the humanitarian segment of the progressive movement. Action to protect workers took the form of a safety movement to prevent occupational accidents and an industrial hygiene movement to control occupational disease. Progressives sought workmen's compensation laws to ameliorate the plight of injured workers and their dependents. The United States government created the Department of Labor (1913), the Bureau of Mines (1910), the Children Bureau (1912), the Office of Industrial hygiene and Sanitation, the forerunner of the Division of Occupational Health in the United States Public Health Service (1914). A few states passed minimal legislation to protect worker health. For example: 1911 Washington passed a compulsory workmen's compensation law, followed by California, Nevada, Illinois, Wisconsin, Kansas, Massachusetts, and New York. In 1913 New York and Ohio established state industrial hygiene units.

Description and definition of workplace hazards by means of industrial surveys and scientific studies took place. Table I indicates some of the best known studies of the early twentieth century.

The activities described point to a new, if limited change in concept toward industrial health. They mark the beginning of a difficult and significant change in both social and scientific attitudes toward industrial health and assumption of responsibility, albeit a limited one, in the public sector for health of workers.

Advances in social legislation during the New Deal renewed interest in occupational health. New federal laws that affected workers' health were passed for example: (1) The National Industrial Recovery Act (declared unconstitutional in 1935) made industrial codes for fair competition which included the regulation of hours and safe

TABLE I

U.S. Department of Labor Reports

Industrial Accidents and Hygiene Series

---

1. Deaths from Lead Poisoning, 1925-27 (June, 1929).
2. Health Survey of the Printing Trades, 1922-1925 (March, 1927).
3. Phosphorus Necrosis in Manufacture of Fireworks and Preparation of Phosphorus (May, 1926).
4. Survey of Hygienic Conditions in the Printing Trades (September, 1925).
5. The Problem of Dust Phthisis in the Granite-Stone Industry (May, 1922).
6. Industrial Accidents (Poisonings) in making Coal Tar Dyes and Intermediates (April, 1921).
7. Carbon Monoxide Poisoning (December, 1921).
8. Causes of Death by Occupation (February, 1930).
9. Preventable Death in Cotton Manufacturing Industry (October, 1919).
10. Lead Poisoning in the Smelting and Refining of Lead (February, 1919).
11. Women in the Lead Industries (February, 1919).
12. Lead Poisoning in the Manufacture of Storage Batteries (December, 1915).
13. Industrial Poisoning Used in the Rubber Industry (October, 1915).
14. Mortality from Respiratory Diseases in Dusty Trades (Inorganic Dusts) (June, 1918).

258

and healthful working conditions, (2) the Division of Labor Standards established in the United States Department of Labor, (3) the Social Security Act of 1935 included provisions to make federal funds available to the United States Public Health Service for research and grants-in-aid to states for public health work including industrial hygiene, (4) 1936 Congress passed Public Contracts Act (Walsh-Healey) which established labor standards for government contracts including requirements for safety and health of workers, (5) 1937 Industrial Hygiene established as a Division of the National Institutes of Health in the Public Health Service, (6) 1937 Fair Labor Standards Act contained the principle of maximum hours and minimum wages for all workers in interstate commerce, (7) 1941 Congress passed the Federal Mine Inspection Act which authorized the Bureau of Mines to make inspections and recommendations relative to health and safety conditions in the mines, (8) 1948 National Labor Relations Board ruled that pensions were within the scope of collective bargaining, (9) the Public Health Service inaugurated a program designed to establish industrial hygiene work in state and local health departments with federal funds made available by the Social Security Act.

By 1948 fifty-eight state and local industrial hygiene units functioned on a full or limited basis in forty-four state health departments, two state labor departments, eight local health departments, the District of Columbia and the territories of Hawaii, Puerto Rico, and Alaska. Concepts accepted today in industrial health were gradually introduced in the 1930's and 40's which included both engineering and medical procedures. Unfortuunately, the reporting of occupational disease remained incomplete. Prior to 1970 the only states with substantial regulatory staffs were California, Illinois, Massachusetts, New York, Ohio Michigan, Pennsylvania and Connecticut.

In 1969 the American public learned that many factories and mines still remained perilous places. Testimony and evidence presented in committee hearings in 1969 and 1970 prior to enactment of federal occupational health and safety legislation revealed that although the high incidence of occupational disease in workers in asbestos, lead, coal mining, cotton-textile and pesticide industries, to name a few, was well known and although there was enough knowledge to control the environment to prevent silicosis, plumbism, mercurial poisoning, and other occupational injuries, the knowledge had not been translated into effective preventive action.

Safety and health laws, historically left to the states were piecemeal, varied in quality, and often unenforced. Every state had workmen's compensation laws, and many had some type of occupational safety and health law, but the pattern of coverage by a jumble of state and federal agencies was inadequate. There was need to move beyond workmen's compensation laws and individual state responsibility to a more comprehensive policy of preventing unhealthy work situations.

The complexity of American industry, its use of sophisiticated processes and new chemicals pointed to the need for research, reporting of statistics on a nationwide basis and federal legislation to protect American workers.

In 1970, in response to the need for federal legislation to protect American workers, Congress passed the Occupational Safety and Health Act. The legislation was the culmination of over half a century of agitation for a safe, hazard-free workplace. A by-product of this law that requires employers to furnish a workplace free from recognized hazards and to comply with occupational safety and health standards is the stimulation of interest in hazards at the workplace among the public and the working population.

Purpose

The purpose of this paper is to portray the altering definition of risks to health associated with the workplace and the manner in which they were approached in twentieth century America, focusing upon the following work related illnesses: 1) silicosis, 2) plumbism, 3) byssinosis, and 4) carpal tunnel syndrome in order to give historical perspective to the significant changes which have occurred in our approach to prevention and control of industrial hazards. We are constantly refining the framework used to assess the health impacts of occupation, both in the scientific and social arenas. The changing perception of hazard results in different societal approaches to deal with risk. Each of the four diseases mentioned above will be presented as a case study to indicate social response to workplace health problems in the past. Historical input is necessary when developing policy options because it adds insight and thus broadens consideration of alternative policies.

II. SILICOSIS

Nature of the Disease Silicosis

Silicosis is one of the pneumoconioses, a group of lung diseases which result from inhalation of excessive amounts of dust in certain occupations. It has been described as "a condition of massive fibrosis of the lungs marked by shortness of breath resulting from prolonged inhalation of silica dust."[1] Silicosis describes the condition caused by inhalation or free silica (SiO_2). Only dust containing free silica causes silicosis. The disease can develop rapidly. In general, it is a chronic or slow developing disease.

Silicosis is usually divided into three stages: slight, moderate and severe. Dyspnea, or shortness of breath on exertion, marks the onset of symptoms. Shortness of breath is at first slight and later increases in severity. It remains an important symptom during the illness. A light cough can also be present. The patient's general condition is unimpaired in the first stage. In the second, or moderate stage, dyspnea and cough become established, diminished expansion of the chest, and patchy dullness sometimes with bronchial breath signs begin to appear and working capacity is impaired. In the third stage dyspnea leads to incapacity. Right heart hypertrophy and then failure may follow. In the slight stage a radiograph indicates the presence of discrete modular shadows. In the moderate stage the whole of both lung fields are occupied by modular shadows and there is some coalescence to form more or less dense opacities. In the severe stage radiographs indicate massive consolidation.[2] Pulmonary tuberculosis often accompanies silicosis; it may be present at any stage of the disease.

The earth's crust contains large amounts of silica. Thus, mining and tunnel building operations are associated with silica hazards. Workers are exposed to silica in the sandstone industry, quarrying, the granite industry, the pottery industry, slate quarrying and dressing, grinding of metals, iron and steel foundries, silica mining, flint crushing, and the manufacture of abrasives and abrasive soaps. American industries consume millions of tons of quartz annually. It is an ingredient of concrete. Crushed sandstone, and quartzite are used for road construction, railway construction, roofing granules, and riprap-erosion control linings for river channels. Sand is used for sand blasting, as a sandpaper, abrasive for polishing and cutting glass, stone and metal and for providing traction on stairs, streets, and rails. Quartz is an ingredient for glass and porclain manufacture, and refractory products such as insulating firebricks, foundry molds and electrical insulators. High quality quartz is fused to make premium grades of chemical and optical glass. Fibers of vitrious silica are used in precision instruments. Large tonnages of quartz are utilized in the production of waterglass or sodium silicate, various sols - very fine dispersions of solids in liquids - used in hydrophobic coatings, organic silicates and silicones, silicon carbide, silicon metal, smelting and flux and alloying in metalurgy.[3]

At Risk

Silicosis, although it is one of civilization's oldest known occupational diseases, remains with us today and represents an important occupational health problem. Table II shows an estimated number of United States workers exposed to silica dust and an estimated number of silicosis cases. The Table omits large numbers of workers employed in the production of chemicals and allied industries, workers employed in heavy construction and others who may be exposed to free silica.

TABLE II[4]
Number of Workers Exposed to Silica Dust and Estimated Number of Silicosis Cases

Industry	Current Number of Exposed Workers	Estimated Number of Silicosis Cases
Mining		
Metal	34,000	816
Coal	126,000	630
Non-metal	7,000	56

Quarry		
Granite	4,000	400
Sand/Gravel	40,000	4,000
Stone, Clay and Glass Products	511,000	31,000
Foundries		
Iron and Steel	192,000	16,700
Non-ferrous	75,000	
Abrasive Blasting		5,000
TOTAL:	1,057,000	59,102

* Source: BLS Employment and Earnings, February, 1978; MSHA

Early Recognition of the Disease

Silicosis has long been associated with the history of mining. From earliest times, miners were exposed to dusts which caused disease and references to dust diseases exist in ancient medical literature beginning with Hippocrates, who noted the connection between dust and disease in a metal miner who breathed with difficulty and had other symptoms similar to those found in silicosis. Thus, the association between mining, dust and disease had been made.

A body of knowledge based upon observations of the association between dust and risk of disease in mining and other dusty occupations continued to grow in volume, but remained severely limited by lack of knowledge of the specific dust diseases and lack of statistics on morbidity and mortality of workers in dusty trades. Silicosis was still unnamed, inadequately defined and misunderstood. Table III contains contributions made toward definition from the 16th Century through the 18th Century on the subject of silicosis.

TABLE III

Date	Author	Contribution and Observation
1556	Agricola	Wrote De Re Metalica, an encyclopedic Treatise on mining and metal industries. Included description of ills and accidents which affect miners.
1567	Paracelsus	Described miners' phthisis.
1614	Martin Pansa	Wrote Consilium Peripneumoniacum.
1652	Ursinus	Believed dust inhalation caused peripneumonia.
1656	Stockhausen	Wrote about miners' phthisis.
1683	Diemerbroech	Described findings in stone cutter's lungs.
1690	Loehness	Described effects of miners' work.
1700	Ramazzini	Wrote De Morbis Artificum - book contained section on diseases of stone cutters.

Industrialization and Silicosis

As industry and mining expanded in the nineteenth century, the incidence of disease caused by dust grew, and received renewed attention from the medical community. In 1870, Visconte coined the term silicosis to denote the pathological condition of lungs resulting from the inhalation of dust.[5] Interest in pigmented and dusty lungs of miners led to observation and study and new contributions were made to the study of dust disease.

Early in the nineteenth century physicians believed that pulmonary pigmentation resulted either from natural black matter, or melanosis, a term for diseased lung characterized by a deposition of black matter. Many physicians who observed pulmonary pigmentation among coal miners believed that a noxious agent of extraneous origin was inhaled into the lung. By the end of the nineteenth century the effects of dust inhalation on the lung had been observed and reported;[6] and the significance of occupation as an influence upon the occurrence of silicosis was established.[7] The manner in which silica dust exerted its effect upon the lung remained a matter of conjecture.

In the twentieth century rapid industrialization caused economic, social and technological change. Dangerous conditions in dusty trades, which had always existed grew with the increase in production, new machines, and larger numbers of workers in mines factories, quarries and dusty industries. New technology, for example, the utilization of machines in mines increased production. At the same time they also increased the amount of dust, creating dangerous and unhealthy conditions. As larger numbers of workers were exposed, the problem grew more pervasive and created renewed interest in occupational diseases, in particular, silicosis.

In the early decades of the twentieth century, German, British, and South African scientists added to the knowledge of the effects of dust on lungs and the disease silicosis. English investigations pointed to free silica as the inciting agent in the disease silicosis. It was also believed that free silica was a factor which increased susceptibility to tuberculosis. As early as 1918 English workers received compensation for disability due to silicosis and tuberculosis. South African research added the following information to the technical picture of silicosis: (1) An essential factor contributing to the development of chronic lung disease was inhalation, over long periods of time, of dust containing free silica; (2) Cases of silicosis can reach advanced stages and end in death without tuberculosis; (3) All mineral dusts are not equally dangerous; the most dangerous ones are characterized by the presence of uncombined crystalline silica; and (4) The smallest particles, about one micron in diameter, are the most dangerous.[8]

Little interest in silicosis existed in the United States until the second decade of the twentieth century. The newly aroused concern was coincident with the progressive movement which sought protective labor legislation and workmen's compensation laws. A series of studies of mining and other dusty occupations revealed that silicosis was a severe problem in the United States. Table IV lists studies related to silicosis conducted between 1918-1935. The coal mining, cement, sandstone, marble, pottery and abrasive industries were studied.

TABLE IV

Date	Title	Gov't. Agency	Author
1917	Siliceous Dust in Relation to Pulmonary Disease Among Miners in the Joplin District	U.S. Bureau of Mines Bulletin No. 132	Higgins, Lanza, Laney & Rice
1918	Mortality from Respiratory Diseases in Dusty Trades	U.S. Bureau of Labor Statistics Bulletin No. 231	Hoffman
1928	The Health of Workers in Trades, I. Health of Workers in a Portland Cement Plant	U.S. Public Health Service Bulletin No. 176	Thompson, Brundage, Russell & Bloomfield
1935	Anthraco-Silicosis Among Hard Coal Miners	U.S. Public Health Service Bulletin No. 221	Sayers, Bloomfield, Dalla Valle, Jones, Dressen, Brundage & Britten

Studies indicated that incidence of silicosis was related to severity of exposure. In mining the studies confirmed that pulmonary fibrosis among hard coal miners was due to silica dust.

Laboratory research also extended knowledge about silicosis, engineering and chemical methods for dust determinations and control were introduced, and roentgenological diagnosis of silicosis utilized.

As a result of research and field studies, much had been learned about silicosis by the 1930's. Silicosis was identified as an industrial disease that resulted from the inhalation of silica dust. Its development depended upon the amount of free silica in the dust, the concentration of dust in a state of fine division in the air breathed, and the duration of exposure to the dust. Physicians had clinically described the disease and diagnosed it with x-rays, history of the patient's exposure, nature of symptoms and physical examinations. The prevention and control of silicosis by using engineering devices was understood. Dust sampling methods existed which could determine the amount of silica, enabling judgments as to the severity of hazard and adequacy of dust control.

The scientific knowledge had not yet been translated into a public policy of control. Silicosis had become a preventable but nevertheless uncontrolled occupational disease. Between 1914 and 1930, compensation for occupational disease was minimal, and up to 1935 not one state which operated under a schedule included silicosis in its list of compensable occupational diseases.

During the Great Depression, as the economic crisis deepened and the number of unemployed grew larger, workers were willing to face any known or unknown danger in order to receive a pay check. It is not surprising that during those years little was done to create hazard free working conditions and that a situation such as the Cauley Bridge incident could occur.

In 1930-1931 the New Kanawha Power Company, a subsidiary of Union Carbide, contracted to drill a tunnel through a mountain at Cauley Bridge, West Virginia to divert water from the New River to a hydroelectric plant. The subcontractor was Rhinehart-Dennis Company. The men employed to drill through the rock inhaled dust and soon complained of shortness of breath and other symptoms of silicosis. According to testimony the employers knew that the rock had a high

514

silica content. An estimated two thousand men (many of them black and unskilled) from mine states worked on the tunnel over a two-year period. Four hundred seventy-six men died and eventually fifteen hundred were disabled.[9]

In 1936 a Subcommittee of the House of Representatives held hearings on the Gauley Bridge disaster and concluded: 1) There was an utter disregard for all and any of the approved methods of prevention, 2) dust was allowed to collect in such quantities that it lowered the visibility of the men, 3) the majority of drills were dry, and 4) no appliances were used on drills to prevent concentration of dust.[10] The hearings alerted the American public to the problem of silicosis and the committee found that silicosis was prevalent in many states where mine and tunnel operations occurred. According to the committee, silicosis was one of the greatest menances among occupational diseases and state laws governing prevention and compensation were totally inadequate.[11] The New Deal and World War II brought about new interest in occupational health. New research efforts, investigations into the extent of silicosis, extension of workmen's compensation to cover occupational diseases in many states and in some states the beginning of occupational health programs all indicate this new interest.

Efforts to control dust in industry employed the earlier conceived essential principle that there is a systematic dose-response relationship between severity of exposure to the dust hazard and the degree of response in the individual exposed. As the level of exposure decreases, there is a decrease in the risk of injury. Thus, the risk becomes negligable when exposure falls below certain tolerable levels. This concept assumes that harmful agents such as silica dust can be dealt with and that human exposure to this potentially harmful agent can be kept within tolerable limits. Control could then be affected by the setting of standards of acceptable levels of exposure referred to by the American Conference of Governmental Industrial Hygienists as Threshold Limit Values (TLVs).

Table V lists some major studies made during the period 1941 to 1964.

TABLE V

Year	Title	Source	Author
1941	The Health of Workers in Dusty Trades - VI. Restudy of a Group of Granite Workers.	Public Health Bulletin No. 269 Fed Sec. Agency	Russell

PHS

1950	Review of Literature on Dusts	U.S. Dept. of Interior, Bureau of Mines, Bulletin No. 48	Forbes, Davenport & Morgis
1956	Some Facts on the Prevalence of Silicosis in the United States	Archives of Ind. Health	Trasko
1957	Control of Silicosis in Vermont Granite Industry Progress Report	Public Health Publication 557 U.S. Dept. HEW	Mosey, Asher & Trasko
1963	Silicosis in the Metal Mining Industry, A Reevaluation 1958-1961	Public Health Service Pub. No. 1071	Flinn, et al.
1964	Twenty-six Years Experience With Dust Control in the Vermont Granite Industry	Industrial Med. and Surgery	Ashe & Bergstrom

18 17

In 1970 Americans learned that accurate statistics refecting the incidence of silicosis were non-existent and that no one knew the full extent of the silicosis problem. Testimony at hearings before the Subcommittee on Labor and Public Welfare of the United States Senate on the Occupational Safety and Health Act described the shortcomings of industrial health efforts in general and showed the need for a comprehensive federal occupational health and safety program. It was clear that without adequate quantitative description of industrial diseases, silicosis included, it was impossible to assess and control hazard. While acknowledging that efforts toward a hazard-free workplace had been made and achievements realized, witnesses also stressed that there was still much to do, including, research, collection of needed statistics, a method of recording and accumulating information and enforcement of a meaningful standard.

Today, thirteen years after the Occupational Safety and Health Act became law, exposure to silica dust and the risk of silicosis still exists for many American workers. Some unanswered questions remain including the extent of silicosis in the United States. We still do not know the fundamental mechanism of the toxic action of silica. Dust suppression methods may be inadequate to control all affected industries. Perhaps we need more accurate methods of collecting and measuring dust samples. However, even without answers to many of the above questions there is enough knowledge to control silicosis through technology.

The significance of the history of silicosis is that it highlights the present dichotomy between possession of sufficient technical knowledge to prevent the disease and failure to eradicate it. In the past, social, economic and political aspects of worker protection received little attention. The risks we once judged acceptable are now being reevaluated in the light of changed social attitudes. Public policy toward occupational diseases such as silicosis now centers on the issues of priorities and the basis for setting standards. Silicosis probably will not be eliminated from the roster of occupational diseases in the United States until there is both scientific and social concensus to support a legally acceptable permanent, enforceable standard.

III. LEAD

The Changing Definition of Lead Hazard

Lead has long been a critical raw material. In the past the benefits of lead usage, when contrasted to associated risks, outweighed the known hazards of this metal used since ancient times for making pipe, paint pigments and ceramics. Industrial growth resulted in the utilization of lead in literally thousands of products in our society.

Lead almost exquisitly illustrates the dilemma society faces in its decision making to control or perhaps even discontinue use of a valuable, but nevertheless potentially toxic material. The health risks linked with continued exposure to certain forms of lead cover an entire spectrum of symptoms with the most advanced referred to as plumbism. Major social and scientific changes have occurred over the years, which have guided our approach to the utilization of lead, a toxic metal essential to modern technology, with a history dating back to antiquity.

Lead (Pb), a bluish-gray metallic element with a high degree of placticity, is widely distributed throughout the world. Since ancient times, lead has been used for making pipe, paint pigments and ceramics. Industrial growth resulted in the utilization of lead in literally thousands of products. Today lead is rolled into sheet and foil and can be made into rods, pipes and tube containers. It is used in construction for roofing, cornices, tank linings, electrical conduit, water pipes and sewer pipes. It is used for yacht keels, plumb-bobs and sinkers in diving suits. Antimonial lead is a major type metal and lead-antimony alloys are used for accumulator plates, cable coverings, ornamental castings and bullets for small arms ammunition. It is a basic ingredient in solder and the barrier that confines dangerous x-rays, a major component in batteries and it is in gasoline.

Xw

New use have been found for lead and old ones discarded, but the danger of disease stemming from lead's toxic properties persists. Today we refer to the effects of exposure to lead as plumbism. In other eras it has been called saturnism, colic, dry gripes, dry bellyache, and potter's palsy.

Lead can enter the body through the respiratory system, or by way of the gastrointestinal tract. It is also possible for certain lead compounds to be absorbed through the skin. Lead in sufficient dosage can affect the gastrointestinal, excretory, nervous, and circulatory system.[12] Acute clinical manifestations of plumbism are (1) intestinal colic (commonest and most painful), (2) lead encephalopathy, (3) attacks of coma, (4) delirium, and (5) deafness, (6) wrist drop, (7) a blue line on the gums, (8) transitory pains in the muscles and joints.[13] Lead can affect the general public as well as industrial workers.

Until recently we knew of only the acute or chronic manifestations of plumbism. In the discussion which follows, those ailments will be referred to as the clinical effects of lead. In the 1960's more subtle manifestations of lead hazard became the subject of much speculation and concern within the medical-scientific community. The subtle manifestations of lead intoxication will be referred to as the subclinical effects of lead in humans.

Early History

Ancient people used lead without understanding its toxic properties, but even at the early stages of metal usage there existed some association between lead and disease. Hippocrates described a severe attack of colic in a man who extracted metals and recognized lead as a cause of the symptoms. By modern standards ancients used an infinitesimal amount [illegible] d [illegible] hen disease did occur it remained largely ignored because exposed workers were often slaves and forced laborers. During the middle ages plumbism affected miners and metal workers. Perhaps plumbism received little attention because it affected only a few who were members of a submerged class.

The amount of lead produced and its utilization grew and changed. By the 16th century Agricola and Paracelsus both imparted information related to diseases of lead miners and lead workers.

In De Re Metallica (1556) Agricola described mining and metallurgy processes. He also included incidental but excellent descriptions of ills and accidents affecting workers. Agricola wrote about mining, smelting, assaying, and extracting ores including lead. He observed that mining is a ". . . perilous occupation to pursue because miners are sometimes killed by the pestilential air they breath. . . Of the illnesses, some affect the joints, others the lungs, some the eyes, and finally some are fatal to men."[14]

Paracelsus in the 16th century observed diseases of miners and the effects of various minerals and metals on the human organism. He wrote, "The miners' sickness is. . . the disease of the miners, the smelterers, the pitmen, and others in the mines. Those who work at washing, in silver or gold ore, in alum and sulfur ore or in vitriol boiling, in lead, copper, mixed ores, iron or mercury ores, those who dig such ores succumb to lung sickness, to consumption of the body and to stomach ulcers; these are known to be affected by miners' sickness."[15]

In the seventeenth century Martin Panes, a physician, wrote, "All those who dig gold or silver ores, salt, alum, sulphur, lead, copper, tin, iron, or mercury are subject to it (disease)."[16]

In the seventeenth century Vernatti, a physician, noted the affects of lead poisoning upon white lead makers. He observed, "The accidents to working men are immediate pain in the stomach, with exceeding contorsions in the guts and costiveness that yields not to cathartics. . ."[17]

Ramazzini, a physician and professor at the University of Modena and later Padua, made a significant contribution to occupational medicine in the eighteenth century and wrote about fifty-four different occupations associated with lead poisoning. He described potters' illnesses in the following manner, "During the process (potting) or again when they use tongs to daub the pots with molten lead before putting them into the furnace, their mouths, nostrils, and the whole body take in the lead poison that has been melted and dissolved in water; hence their hands become palsied, then they become paralytic, splenetic, lethargic, cachetic, and toothless so that one rarely sees a potter whose face is not cadaverous and the color of lead."[18]

In general, since the usage of lead in preindustrial society was relatively speaking minimal and the number of workers affected was small, the benefits of mining and using lead apparently outweighed the risks.

At the same time that physicians associated lead with toxic effects in workers it also affected unsuspecting members of the general population. "Dry gripes" was associated with one of colonial America's early industries, rum distillation. Lead worms and still heads contaminated large quantities of rum. Pewter, an alloy of tin and lead, was commonly used in the seventeenth century for utensils such as teapots, mugs, creamers, tankards, platters, basins, and pitchers which came into contact with food.

In England the Devonshire colic epidemic raged for approximately one hundred years. The "colic" was attributable to lead which entered the bodies of the cider drinking population of Devonshire because of extensive reckless use of lead in the apparatus of cider making and storage.

Although it was known since ancient times that lead had toxic properties, physicians used a variety of lead preparations for therapeutic purposes. During the eighteenth century some physicians believed that lead in proper dosage, could cure many ills although it had been noted that the remedy often proved worse than the disease. Semmes, in a nineteenth century medical treatise, claimed lead therapy could cure consumption, diabetes, dysentery, and epilepsy.[19] It is a paradox that while the hazards of this metal, both to the working population and the general public grew increasingly apparent, it still retained its place as a medicine.

All of the observations of the association between lead usage and the risk of poisoning were severely limited by a lack of knowledge of the disease proper and the still relatively limited use of lead.

Industrialization and Lead

Lead usage reflects the growth of technology and industry. By the first quarter of the twentieth century over one hundred ten industries used lead in some form.[20] As the hazard associated with lead affected larger numbers of people it began to receive more attention. Thus industrial growth contributed to increased interest in lead poisoning as a significant increase of workers at risk generated new interest in an old disease.

Four factors account for renewed interest in health hazards due to lead. They are: (1) increase in lead usage, (2) more data relative to the incidence of lead poisoning, (3) better medical understanding of the lead hazard and the disease proper, and (4) a change in social attitudes. Pioneers in the field of industrial health, who were aware of the great incidence of plumbism in American mines and factories, spearheaded a battle for legislation to provide more salubrious factory conditions. They made contributions to the knowledge of the action of lead on the body, the prevalence of occupational plumbism in various trades, the period of exposure before poisoning occurs, the different forms which the intoxication assumes and the dangers which must be guarded against to protect workers in lead trades.

Efforts of pioneers in the field of industrial medicine, social legislation, the rise of unions, new scientific knowledge, and new engineering devices tended to reduce the hazard of lead. Indeed, the majority of professionals in the field of occupational health believed that the hazard of lead poisoning could be controlled to an acceptable degree and the risks reduced to a tolerable level.

The efforts to clean up lead industries employed two essential assumptions related to in-plant safety. First, there is a dose-response relationship between severity of exposure to the hazard of lead poisoning and the degree of response in the exposed individual. As the level of exposure goes down there is a graded decrease in the risk of injury. The risk becomes negligible when exposure falls below certain tolerable levels. These assumptions assert that agents such as lead can be dealt with safely and therefore do not have to be eliminated completely to keep industrial workers safe. This is the philosophical basis for ideas which prevail today in industrial health.

Changing Concepts of Lead Hazard

However, in the 1960's, scientific, social, and economic changes and a proliferation of lead products resulted in a new concept of risk associated with the usage of lead in our society. This concept raises questions relative to subclinical effects of lead in human beings. A segment of the scientific community is suggesting that the criteria used to judge risk, for example, clinical symptoms of plumbism are inadequate.

The modern concept about lead hazard stems from new and varied uses of lead which distribute it as never before throughout the environment and expose the worker and the general population. Trace quantities of lead can be found in food, beverages, and in the air we breathe. The sources are industry, smelting, incineration, combustion of coal, and motor vehicles. These trace quantities of lead permeate all aspects of the environment including vegetation and small living animals. The introduction of tetraethyl lead as an additive to gasoline in 1923 increased lead in the atmosphere. Major lead utilization shifted to storage batteries and gasoline additives.

In the past perhaps the most widely accepted criterion for lead intoxication was the amount of inorganic lead in the blood, usually expressed as mg lead 100/ g whole blood. The basis for the criterion is that lead is stored in the body, primarily the calcareous portion of the bone, and the blood lead is in equilibrium with the lead storage depots. Hence, as increased quantities of lead are stored in the body, the blood lead level increases. Physicians have guided themselves by various levels of blood lead intoxication. For example, a concentration of 0.08 mg lead/100 g of whole blood has been the guideline for concern in industrial workers. It should be noted that clinical symptoms are rarely associated with this level. Although the sensitivity of the population at risk differs, according to Patty, clinical symptoms do not usually appear until a level of 0.15 mg lead/100 g whole blood is reached.[21]

The advocates of the modern risk concept of lead suggest that certain long-term health effects may occur in the general population exposed to lead from many sources in the community.[22] The concern of the advocates of the new philosophy of risk has nothing to do with the old criteria of blood lead, and one might say an entirely new concept of lead injury has been introduced.

Because of the proliferation of lead products and the resulting introduction of lead within all aspects of our environment, the ability to make more accurate and sensitive measurements and a more concerned attitude toward the welfare and health of the general population, new questions relative to subclinical effects of lead in human beings have been raised, effects not measurable by any of the guidelines previously used. This new concept of risk, which focuses upon trace amounts of lead in vegetation and food supplies, questions the long-term effects of lead in our ecological system.

The influence of lead on cell growth, the effects of lead on mental development, the effects of lead on lifespan, and the concentration of lead in bone are some questions raised in examining potential hazards from low-level exposures to lead. A large body of recent experimental work is focused on the subclinical effects of lead.[23]

At the same time that this new concept of lead injury is being explored and refined, a number of other researchers continue to study lead concentrations in blood and have thus far reached the conclusions that there is not a significant health threat now or in the foreseeable future. As a result, lead in the environment has become a controversial issue. An ancient disease once considered acceptable has been reevaluated and become a serious medical, human, and social problem. This change of focus is based on new scientific data which has changed our perceptions of the earlier manifestations of lead poisoning on the health of industrial workers and the general population exposed to lead insult.

Summary

Thus, the new uses of lead, new ability to make more accurate measurements, advances in biochemical science and new attitudes toward public health have all meshed to challenge the traditional concept of lead poisoning. In the dialogue that has been initiated between those who see a threat and those who do not, the concept of health risk and even the concept of disease itself are undergoing redefinition.

This brief historical perspective on plumbism has indicated that at early stages of scientific and technological growth, which involve the use of needed materials, we often accept the jeopardy to health incurred by utilization of hazardous materials. In many cases the perils are unknown. As technology becomes more refined, we become aware of more subtle hazards; and as social philosophy changes, new attitudes toward risks also become more humane. New awareness of danger and the concomitant change in social philosophy may cause a redefinition of disease and a reevaluation of the continued utilization of the material.

IV. BYSSINOSIS

Byssinosis, an occupational respiratory disease caused by exposure to cotton dust, has been until recently either ignored, misunderstood, or its existence actively denied. Although association between dust and respiratory disease and the process of definition and identification of the disease, so closely associated with cotton dust, began early in the history of the cotton textile industry, the reeded action to prevent dust induced disease lagged far behind the growth of the textile industry. Recognition of byssinosis as an occupational disease did not occur in the United States until the 1960's.

The history of the growing awareness of illness associated with the manufacture of cotton textile and the eventual changes in policy toward this occupatinal disease illustrates the impact that scientific, technological, socio-political and economic factors have upon occupational health policy decisions. Recent debate about policy toward byssinosis has embroiled labor, the textile industry, government agencies, scientists, and lawmakers in controversy; creating political and ideological polarization and inhibiting the movement for adequate and reasonable legislation to protect cotton workers at risk.

The debate has also brought into focus the altering perception of hazards and the continually changing definition of risk, clearly illustrating that risks we once judged as acceptable are being reevaluated in the light of new scientific evidence, new technology, and changed social attitudes and values.

Description of Byssinosis

Byssinosis, commonly called brown lung, occurs in the presence of cotton, flax, or hemp dust. Its initial acute symptoms are: tightness in the chest, dyspnea, and a cough after returning to work on Monday. A decrease of ventilatory capacity occurs during the workday. Later symptoms extend to other workdays. Eventually, there

1-29

is a chronic stage, resulting from continued exposure over a long period of time, with severe continuous dyspnea, chronic cough, and permanent ventilatory insufficiency referred to as irriversible and disabling chronic obstructive pulmonary disease (COPD). Total disability ~~and death often~~ follows. The acute effects of exposure may be reversed, but long-term, chronic effects cannot be reversed.

At Risk

Because byssinosis occurs in the presence of cotton dust. At risk, are workers in cotton mills, but others involved in the processing of cotton from ginning to finished goods can manifest symptoms. The United States Department of Labor estimated that about 84,000 active workers currently suffer from byssinosis in all grades.

A study of cotton textile workers estimated that 30,000 active and retired textile workers suffer totally disabling byssinosis, and that since textile workers are employed for an average of 35 years, about 800 of these workers become totally disabled each year.[24]

Early Association Between Exposure to Cotton Dust and Respiratory Illness

Association between exposure to cotton dust and the development of acute or chronic respiratory illness was made even at the beginning mechanization of the cotton industry. Descriptions of abnormal conditions of the respiratory tract among cotton workers appeared as early as 1832 when Dr. Kay, a resident of Manchester, England, who worked at the Ardwick Dispensary, described "Spinners' Phthisis." He wrote,

"In many cases which have presented themselves at the Ardwick and Ancoats Dispensary, the disease induced has appeared to me to differ from ordinary chronic bronchitis. In the commencement of the complaint, the patient suffers a distressing pulmonary irritation from the dust and filaments which he inhales. Entrance into the atmosphere of a mill immediately occassions a short, dry cough, which harasses

> him considerably in the day, but ceases immediately after he leaves the mill and inspires an atmosphere free from foreign molecules. These symptoms became generally more severe, the cough is at length very frequent during the day, and continuous even after its employments have ceased, disturbing the sleep, and exhausting the strength of the patient, but it is accompanied with little or no expectoration. In this stage, he seeks medical aid. He is harassed with a frequent cough, which is often excited by speaking, by slight exertion, or a change of temperature. The patient sometimes expectorates a little but the cough is often dry and short and recurs incessantly. He experiences a diffused and obscure sensation of uneasiness beneath the sternum, in sudden exertion a pectoral oppression ensues, arising as it were from an inability to dilate the chest freely in the ordinary inspirations. . . The patient is easily afflicted with acute bronchitis on exposure to its existing causes."[25]

American reference to mill workers' health in the nineteenth century also exists. Dr. Josiah Curtis attempted to discover the effects of the factory upon health of workers. In 1849 he noted the effects of poor ventilation and high temperature upon the health of cotton workers.[26] At a hearing for a 10-hour day before a legislative committee in 1845 in Massachusetts, a witness, Miss Eliza R. Hemingway said, "The working time was too long; the meal times too short. The air in the factory was bad; over 150 persons worked in one room, for example, where 293 small lamps and 61 large ones burned morning and evening during the winter months. There was no day when fewer than six girls stayed away from work because of illness; as many as 30 had been known to remain at home on one day for that reason. In all seasons flying lint was a source of great discomfort.[27]

Health problems related to working conditions in cotton mills were also noted in Cohoes, New York. A report in the *Medical Press* in 1880 stated, "Bronchitis was most pronounced among cotton mills hands." The article's author suggested that operatives use a respirator made of cotton wool over their mouths.[28]

The _30th Annual Report of the Massachusetts Bureau of Statistics of Labor_ included a discussion of conditions relating to health in cotton mills. "... cotton fibers constant circulation through the air get into the throat and give everyone the appearance of having a cold."29

In 1863 an article published in _Lancet_, a British medical journal, described the health effect of cotton dust upon operatives in a mill. "The first process the raw cotton undergoes is the mixing of one staple with another. Much dirt and dust is disengaged in this operation. The respiration is affected from the dust irritating the respiratory passages of the mixers, and coughing and sneezing are the frequent consequences, which disengage from the bronchial membrane a quality of salty colored expectoration, which when placed under the microscope, is seen to consist of very fine short fibers of cotton in air bubbles and mucus. . . After passing the mixers the cotton passes through the hands of the willowers or scutchers. When ventilation is not assisted by ventilation chimneys of tin or wood, which takes off more effectually the dense atmosphere with which the rooms are charged, the willowers and scutchers suffer in the same manner as the cotton mixers. From the immense velocity of the machines used, the revolutions being 1500 per minute, the quantity of short fibers of cotton set afloat in these rooms is very great. It would be difficult to recognize a man at twelve yards distance from the density of floating fibres modified, of course, very much by a wet or dry day. The strippers, grinders, and cardroom hands are engaged in the next process of cotton manufacture. They mostly suffer from a spasmodic cough, sore throat, expectoration of blood, pneumonia, and confirmed asthma with oppression of the chest. . . A carder seldom lives in a cardroom beyond forty years of age. Many have to give up working much younger. Forty-five to fifty years are their average ages."30

Once it was recognized that abnormal conditions of the respiratory tract occurred among cotton operatives, it was then necessary to show that abnormal conditions of the respiratory tract occurred more often among cotton operatives than among the general population, and that the abnormal conditions and illness could be attributed to the inhalation of cotton dust. It remained then to describe theetiology of the disease caused by inhalation of cotton dust. Thus, in order to begin to control the respiratory illness caused by cotton dust, it had to be, shown to exist, described, named, and its etiology understood. Investigations into the nature of disease caused by cotton dust took place in the 19th century, and a long standing and world wide interest in the effects of exposure to cotton dust upon the respiratory tract existed early in the twentieth century. By mid-century (1947), the United States Public Health Service published a review of literature related to affectations of the respiratory tract in cotton workers.[31] It contained 267 references to cotton dust and health from 1829 to 1947.

The literature review included thirty-six surveys of cotton workers' health from 1827 to 1946. This early literature on cotton workers' health stressed occupational hazard as well as other cotton workers' problems that could affect health including low wages, inadequate diet, poor housing, and sanitation. (See Table VI, Surveys of Cotton Workers' Health, 1827-1946 - included at the end of this section).

Thus, references to respiratory disease associated with cotton manufacture existed from the beginning of the history of mechanization of that industry. Proust first used the term byssinosis in 1877. Before that and well into the twentieth century, observers gave the disease many different names. Two English studies are worthy of note. The first in 1908 by Collis examined 126 men employed in Blackburn, England and found 73.8% complaining of, or suffering from an asthmatic condition due to inhalation of dust. Collis noted the association between length of employment, and prevalence and described the symptoms of byssinosis.[32] Hill performed the second study. He inquired into sickness among cardroom operatives compared with cotton operatives in the same spinning mills and made the following conclusions (1) Strippers and grinders, the cardroom workers exposed to the maximum amount of dust, and other cardroom workers have in comparison to other operatives in the cotton industry and in comparison with all males in England and Wales high death rates from rspiratory diseases. (2) Among cardroom workers after thirty there is a pronounded excess of illness from respiratory illness. (4) The excess of respiratory illness among cardroom workers cannot be easily explained by any other factors except environment. (5) There is no evidence of an excess of respiratory illness among the younger workers who have only worked under modern conditions. It may be that some years exposure is necessary before the effect of environment will be shown. "It seems evident that the conditions in the cardroom before localized exhaust ventilation and vacuum for stripping were introduced were distinctly unfavorable to health. Such extreme conditions no longer exist and it is to be hoped that the injurious effect upon health has changed with the change in environment. In the absence of positive evidence that this is so, the reduction of the operatives exposure to dust and fibre, to the maximum extent possible, is obviously desirable."[33]

In 1936, Prausnitz introduced the term "Monday fever" into the literature on byssinosis. Textbooks, for example, *Diseases of Occupation*, included byssinosis as an occupationally caused disease. "There are various forms of dust diseases of the lung or pneumokonoises, e.g. anthracosis due to coal dust; chalicosis and silicosis, due to sandstone and mineral grit; sialerosis, due to iron; and byssinosis, to cotton fibers."[34]

Statistical information on the health of cotton workers in England indicated a high rate of mortality from respiratory disease, and emphasized that high mortality from respiratory disease, occurred chiefly among cardroom and blowroom hands, strippers and grinders. Mortality from respiratory diseases was considered due to dust rather than heat and humidity. Although the mode of action of the dust was not completely understood, evidence existed to indicate that dust could act a a mechanical irritant.

ß 34

Thus, by 1940 a literature existed pertaining to respiratory tract effects among workers exposed to cotton dust. From that literature the following generalizations can be made as to what was known about byssinosis: (1) it had been named and described; (2) while cotton dust was not the only hazard in the textile mills, it was assumed to be principle one with regard to respiratory tract ailments; (3) the early stages of processing (ginning, bale-breaking, picking, and carding) involved greater dust hazard than spinning and weaving; (4) byssinosis occurred in workers with long and continuous exposure to cotton dust; (5) byssinosis was observed in all countries with a coton textile industry; (6) the literature on the subject of health of cotton operatives was international, with the British work most complete; and (7) byssinosis represented the end result of a chronic process. Complete data did not exist relative to the quantities of dust in the atmosphere of cotton factories or the physical, chemical and biological composition of cotton dust. In 1940, the British passed legislation recognizing byssinosis as a compensable industrial disease.

The American Experience: Tardy Recognition

Until the 1960's, in spite of its widespread recognition, the problem of serious dust disease among cotton workers was hardly known to exist in the United States, a national with a large textile industry.

In order to comprehend American tardiness in recognizing the existence of byssinosis as an industrial disease, it is necessary to understand subsequent industrial relationships in mill towns of the southeastern United States and a series of developments over several decades.

Textile manufacturing is one of the largest industries in the United States and employs almost one million workers. Its largest division, cotton textiles, employs approximately two hundred fifty thousand workers. Over ninety percent of the manufacturing occurs in

T35

southern states. Cotton mills dominated the political and economic life of the New England towns where this industry originated and continued to do the same in the South where they eventually relocated at the end of the nineteenth century, ushering the industrial revolution into the South.

By the second half of the twentieth century, most cotton textile mills had relocated from New England to a small area on the southeastern seaboard. In 1966, New England cotton mills comprised approximately three percent of the total.[35] Between August 1, 1972 and July 31, 1973, 13.2 million bales (about 3.3 million tons) of cotton were produced in the United States. About 74 million bales were processed in the United States and the number of workers involved in cotton fiber processing in 1973 was estimated at 800,000.[36]

Cotton Industry In The South

The factors which favored the growth of new industy did not always help working people. Indeed, the availability of a supply of cheap and tractable labor in the South is such an example. "Competition for jobs was so severe that wages were minimal, with the manufacturer furnishing housing and many other facilities for the maintenance of life. Additional thousands of tenant farmers and mountaineers stood ready to take the jobs of mill workers who, through strikes or other forms of non-cooperation might seem to employers and to southern communities to have forfeited their right to employment. Under such conditions, employers had a high competitive advantage over northern mills at a time when lack of capital and experience made an advantage necessary."[37] Town leaders looked upon industrialist as pioneers and made numerous concessions to obtain mills. They lowered or rebated taxes, avoided restrictive legislation and condoned low wages.

Mill owners provided housing and other facilities for workers and assumed control over their use. In this way, the mill village offered owners a means of social control over the workforce. "The first generation of mill workers appears to have been, nevertheless, patient and long suffering in spirit. Its members came to mill villages as refugees; for the most part they had been unsuccessful in previous economic pursuits, and acceptance of industrial employment represented a last stand against pauperism. They had been accustomed to working from sunrise to sunset without murmuring and to expect little in return."38

The village church also contributed to labor discipline in mill towns. Liston Pope in his study of the church in the growth of the textile industry, Millhands and Preachers, stated that the contribution of the church lay in the discipline provided through moral supervision of workers. He said, "The greatest contribution of the churches to the industrial revolution in the South undoubtedly lay in the labor discipline they provided through moral supervision of the workers. From the beginning, employers used the church as vehicles of welfare work and supported church programs."39 Support worked two ways. The church played a role in social control of workers and the mills supported the church.

Social control led to fear of challenging the system. The size and extent of social control exerted in southern mill towns kept workers, preachers, the media, school boards, doctors and lawyers quiet. It accounts for lack of organization among workers.

The labor strife which occured in southern mill towns in the 1920's and 30's, also accounts for the lack of organization in the later part of the 20th century. Textile workers went on strike in Henderson (1927), Gastonia, Elizabethton and Marion (1929), Danville (1934), Greensboro (1938), High Point (1939), and on a general strike (1934). Complaints of workers included long hours, low wages, the stretch out system, parternalistic mill villages, and the denial of the right of workers to organize in order to limit control of employers through collective bargaining. The strikes were unsuccessful. In some places, Gastonia, for example, strikes ended violently. Gastonia officials appealed to the governor of North Carolina for intervention and the national guard, sent by the governor, precipitated violence. During the general strike of 1934, martial law was declared. The National Guard and state troopers helped to break the strike. Sixteen workers lost their lives.

A marked degree of power was exerted over strikers because the mill villages were company controlled. "In a typical mill village in the strike areas, the manufacturer owns a good many other things besides places to house his employees. He owns the homes to be sure, he also owns the store, the church, the recreation center, the school, the drugstore, the doctor, the teacher, and the minister. He owns the community and he regulates the life that goes on there after the days work is over in his mills. He has the power to discharge the worker at the mill, to refuse him credit at his store, to dump a worker's furniture out of a house, to have him expelled from church, to bar his children from school, and to withhold the services of a doctor or a hospital."[40] These extreme conditions no longer exist but they help explain why the southern textile industry is still largely unorganized. The Amalgamated Clothing and Textile Worker's Union did not begin to fight for recognition of byssinosis as an industrial disease until the early 1970's.

Physicians added to the problem of tardy recognition of byssinosis. The testimony of Dr. I.E. Buff at the 1970 Senate hearing on occupational safety and health illustrates this problem. Dr. Buff said, ". . . then you go and ask the doctors, 'how about this byssinosis?' white lung or cotton dust diseases, and they [illegible] even answer you sometimes. Let's talk about the pathology of the disease. There have been very few people who have ever studied the pathology and yet down there you have one after another that die and no one takes the time to take the tissues of the lung to find out what dust is doing to the cells. Because of the control of the big interests, the dominant forces in the four states, (North Carolina, South Carolina, Virginia, and Georgia), the doctors are afraid to move.

This is an awful thing. The doctors will not chip the establishment. One doctor told me that if I said somebody had cotton disease they would run me out of the town. Another doctor says it would be unhealthy - doctors of medicine."[41]

The active denial of the existence of byssinosis by the cotton industry is another reason for non-recognition although medical studies for over one hundred years clearly established the existence of byssinosis. As late as 1976 at a stockholder's meeting of J.P. Stevens, in New York, Board Chairman James D. Finley said, "Byssinosis is something that is alleged to come from cotton dust. It is a work that's been coined, but it has no meaning.[42] In 1969, an editorial stated, "We are particularly intrigued by the term 'byssinosis,' a thing thought up by venal doctors who attended last year's ILO meetings in Africa where inferior races are bound to be afflicted by new diseases more superior people defeated years ago."[43] Robert T.P. DeTraville, a physician employed by the Industrial Health Foundation, an organization retained by the American Textile Manufacturers Institute to study the problem of byssinosis said, "At a meeting we held recently of the foundation's advisers to discuss byssinosis, we concluded that it is best described as a 'syndrome complex' rather than a disease in the usual sense."[44]

Another factor which may have impeded recognition of byssinosis was studies conducted by the United States Public Health Service in the 1930's which led many to conclude that dust concentrations in cotton textile mills were low and that workers were not at risk. "The low concentrations of dust encountered in this particular study made it apparent that no adverse effect on health was to anticipated from this source."[45]

A textbook published in 1954 stated, "In Britain respiratory disability among cotton textile workers is something of a problem, and the situation seems to be quite different from ours in the United States. Byssinosis, the respiratory complaint resulting from cotton dust inhalation, is almost unknown in the United States probably because of our relatively high degree of mechanization."[46]

Technological change also contributed to the problem of byssinosis. Modern technology increased the amount of dust in cotton mills. Over ninety-seven percent of the United States cotton crop is machine harvested.[47] The machines pick up more debris along with the cotton than did manual pickers and it is crushed and becomes airborne. Speedier machines intensify the risk of byssinosis to workers in the end process by releasing larger quantities of dust. Air conditioning distributes air contaminated in one part of the mill throughout the rest of the mill.

All of the above circumstances help to explain the reasons for the tardy recognition of byssinosis as a disease of cotton mill workers in the United States.

Recent History

The complex mix of social, political, economic, and technological factors fostered the illusion that byssionosis did not threaten American cotton textile workers. It persisted until the 1960's. In 1960, British investigators McKerrow and Schilling studied two American cotton mills to determine why byssinosis presented a problem in England, but not in the United States. In both mills investigated they found wokers with typical histories of byssinosis.[48]

Other investigations followed. Dr. Arend Bouhuy's data on cotton wokers with respiratory disease in three southern states indicated that disabling byssinosis occurred in the United States and suggested that hundreds of cotton workers suffered from byssinosis in its early as well as late stages.[49] Bouhuys and his colleagues noted that wherever the diagnosis of byssinosis in a small number of cotton wokers prompted epidemiological studies, many more worker, similarly effected, were identified.

In 1969, Zuskin and others made field studies to obtain further data on byssinosis in the United States.[50] It was noted that technological changes in the cotton industry caused increasing amounts

40

of trash in baled cotton due to the general use of cotton picking machines, and speculated that a component of the trash, bracts, contained an agent or agents which cause bronchoconstriction in man and histamine release in human lung tissue.[51] Other recent developments, for example, the high speed carding machines produce more dust than did older machines operating at lower speeds. "Thus, several technological changes have occurred in the industry which may account for relatively high prevalence of byssinosis in the face of relatively low dust levels."[52]

By 1969, the members of the scientific community had generated data indicating that byssinosis did occur in the United States cotton industry. They suggested the need for adequate population studies to assess the full extent of the problem, while at the same time stressing the need to prevent byssinosis in the cotton textile industry. The elements of a preventive program were well known, i.e.: (1) adequate dust removal techniques, (2) periodic check of airborne dust concentrations, (3) pre-employment medical examination, and (4) periodic medical surveillance of workers, including use of lung function tests. During the 1970's, Arend Bouhuys and other concerned scientists continued their research activities.

As a result the National Conference on Cotton Dust and Health was held in Charlotte, North Carolina on May 2, 1970 to assess the health problem related to cotton dust exposure. Participants included scientists, representatives of industry, textile unions, government agencies (state and federal) and private physicians. The purpose of the conference was to explore the present knowledge of byssinosis, and to summarize the state of the art concerning applicability of health satndards and environmental technology. A summary of the conference stated, "Byssinosis is a respiratory disease of occupational origin which occurs throughout the world among workers processing cotton, flax, or hemp. Although the symptoms are clearly recognizable, the specific agent responsible for the symptoms has not been defined. The prevalence of the disease can be controlled by reducing the exposure of the workers to the airborne dust associated with the process.[53]

During the 1970 hearings before the Senate Subcommittee on Labor and Public Welfare on proposed legislatin for occupational safety and health, congressional attention was focused upon occupational safety and health problem, including those of the cotton textile industry. Testimony indicated that no effective government regulation of the hazard of cotton dust existed on either the state or federal level,[54] and that workmen's compensation laws were woefully inadequate.[55]

At the same hearings a statement filed by the American Textile Manufacturers Institute implied that byssinosis was not a problem[56] The American Textile Manufacturers Institute stated in the same document that ". . . it has set out to determine whether or not there is a respiratory problem peculiar to textile workers, and if there is one to ferret out the causes."[57]

In order to make workers, the public, physicians, compensation boards, and industrialists recognize the existence of byssinosis, the Carolina Brown Lung Association organized and held its first meeting in 1975. The Carolina Brown Lung Association, composed mainly of textile workers, sought to organize mass filings of brown lung compensation claims, to draw public attention to brown lung (byssinosis) and to identify workers with breathing problems. The Carolina Brown Lung Association organized clinics to education victims, doctors, the public, and active workers about byssinosis and did much to alert the public about brown lung. In 1977, Carolina Brown Lung members testified at the Occupational Safty and Health Administration hearing for a cotton dust standard.

By the mid-seventies, activity generated by the scientific community, public interest groups, and labor had created public awareness for byssinosis as an occupationally caused disease. In that time period the new social awareness and a changed social attitude toward occupational disease was manifested in the passage of the Occupational Safety and Health Act of 1970. The Act created a regultory agency, OSHA, charged with promulgation and enforcement of

42

workplace standards.

In 1968 when the Secretary of Labor promulgated a threshold limit value for cotton dust (TLV) of 1,000μg/cum by adopting the federal standard which existed for federal contractors under the Walsh Healey Act, the first legally enforceable exposure limit to cotton dust was established in the United States. The American Conference of Governmental Industrial Hygienists (ACGIH), a private standard setting organization, originally developed the TLV for cotton dust. It was not an enforceable standard. Standards did not become legally enforceable until the Occupational Safety and Health Act of 1970. Then, in accordance with the purpose of the Act, to assure as far as possible safe and healthful working conditions for working men and women, the Congress vested authority in the Secretary of Labor to set mandatory safety and health standards.

There are a number of complexities attendant upon setting standards. One must assume that in order to set a standard there is evidence that presumes predictive validity for the effect that will follow if the standard is exceeded. Along with this scientific component there is a value component which asks how much responsibility for health a society will assume. Society must believe that a problem requires attention and must be willing to pay the price to alleviate the problem. Inevitably the following questions are raised: Do the benefits of health protection warrant the expense of an effective standard? Do the benefits of health protection outweigh the risks of lack of protection?

On September 26, 1974, the director of the National Institute for Occupatinal Safety and Health submitted a criteria document to the Secretary of Labor. It contained NIOSH recommendations for a new cotton dust standard. On December 27, 1974, the Occupational Safety and Health Administration published "advanced notice of proposed rulemaking," and requested that intrested persons submit their views on cotton dust and the NIOSH criteria document. The Textile Workers Union and the North Carolina public interst groups requested that the

TK 43

standard be set at 100 μg/cum rather than at 200 μg/cum as the criteria document had suggested. On December 28, 1976, OSHA published its proposal to revise the existing standard. It called for permissible exposure limit (PEL) of 200 μg/cum of vertical elutriated cotton dust for all segments of the cotton industry, proposed medical surveillance of workers, detailed the methods of implementation and contained provisions for employee exposure monitoring, employee training, work practices, recordkeeping, and methods of exposure control.[58] OSHA held hearings on the proposal in April and May of 1977 in Washington, D.C., Greenville, Mississippi, and Lubbock, Texas. The record of these hearings contains over 100,000 pages of documentation and testimony.

The hearings illustrate the complexity of the issues inherent in framing a standard. All parites had their say at the public hearings, often contradicting each other and stating a number of different and opposing viewpoints. Witnesses incuded manufacturers, employers, lobbyists, lawyers, cotton workers, union representives, public affairs groups, physicians, scientists, statisticians, economists, and industrial hygienists. The American Textile Manufacturers Association, the Amalgamated Clothing and Textile Workers Union, the Occupational Safety and Health Administration, the National Institute for Occupational Safety and Health, the Carolina Brown Lung Association, the North Carolina Public Interest Research Group, the National Organization of Women and others came together to testify and to represent each of their constituent's viewpoints. The final standard was based upon the record of the proceedings which incuded social, technical, and economic inputs.

OSHA's stated viewpoint was that it believed, "The overwhelming scientific evidence in the record supports the finding that cotton dust produces adverse effects among cotton workers. While gaps exist in the understanding of the etiology of respiratory disease caused by cotton dust and their progression from acute to chronic stages, the evidence in the record supports the fundamental connection between cotton dust and various respiratory disorders in both the textile and non-textile industries. Byssinosis is the specific respiratory disease attributable to the action of cotton dust on the respiratory passages."[59] OSHA believed that the continuing scientific debate over etiology did not detract from the conclusion that cotton dust causes respiratory illness and that enough information existed to warrant controlling the disease byssinosis. The American Textile Manufactures Institute did not have the same viewpoint, insisting that more research was necessary before a standard could be decided upon and that the standard requested by OSHA was too stringent, not economically feasible and harmful to the cotton industry.

During the hearings, scientific studies were cited to document the relationship between byssinosis and cotton dust exposure. The American Textile Manufacturers Association contested work of Merchant which documented dose-response relationship and which provided support for exposure limits.[60] ATMI sought to minimize the risk associated with cotton dust exposure.

The ATMI objected to many of the provisions in the proposal including the definition of cotton dust, permissible exposure limits, exposure monitoring and measurement, methods of compliance, medical surveillance and monitoring.[61]

The issues of technological feasibility and economic impact were also addressed. The Research Triangle Institute prepared a document on technological feasibility and economic impact, stating as its primary objective "to provide as thorough an assessment as possible of the technological feasibility of controlling cotton dust to exposure levels being considered by OSHA for inclusion in a cotton dust standard, and the economic impact that compliance with the proposed standard may have on industry and the economy.[62] The RTI document stated, "The principal benefit that might be expected to result from implementation of the proposed standard are reduction of the prevalence of byssinosis and cases of byssinosis avoided.[63] With respect to economic impact RTI said, "Although impact on any one firm cannot be specified in advance, nothing in the cotton-textile industry

XVI 45

as a whole will be seriously threatened by the impact of the proposed standard for control of cotton dust exposure."[64]

At the hearings, Robert Soule, an industrial hygienist, stated, "In summary, for reasons described, it is my opinion that compliance of all segments of the cotton industry with the proposed standard for exposure to cotton dust is technically feasible."[65]

The Council on Wage and Price Stability also prepared a document on the proposed standard and came to a different conclusion. "We believe that the proposed standard could impose excessive costs upon the cotton processing industry unless the standard is carefully formulated to take into account cost-effectiveness considerations and the potential for including positive cost-reducing innovations.[66]

OSHA issued its final cotton dust standard on June 23, 1978. The standard established a permissible exposure limit (PEL) of 200µg/cum for yarn manufacturing, 750µg/cum for slashing and weaving operations, and 500µg/cum for all other processes in the cotton industry and for non-textile industries where there is exposure to cotton dust. The standard also provided for employee exposure monitoring, engineering controls and work practices, respirators, employee training, medical surveillance, signs, and recordkeeping.

OSHA stressed that the standard was designed to attain the highest degree of health and safety for cotton workers. It did not base exposure levels primarily on cost-benefit analysis. "In making judgments about specific hazards, OSHA is given discretion which is essentially legislative in nature. In setting an exposure limit for a substance like cotton dust, OSHA has concluded that it is inappropriate to substitute cost-benefit criteria for the legislatively determined directive of protecting all exposed employees against matreial impairment of health or bodily function."[67] According to OSHA the standard was justified if compliance costs were not overly burdensome and the benefits appreciable.

On October 24, 1979, the United States Court of Appeals for the District of Columbia issued an opinion upholding the standard. The court also held that the standard was economically and technically feasible. The court rejected the argument that OSHA must conduct a formal cost-benefit analysis before promulgating the standard.

On June 17, 1981 the United States Supreme Court upheld the cotton dust standard. In a five-to-three decision it rejected arguments by the textile industry that the cotton dust standard was invalid because the Occupational Safety and Health Administration failed to show that the cost of compliance was justified by the health benefits to workers. Justice Brennan in the majority statement said, "In effect then, as the Court of Appeals held, Congress itself defined the basic relationship between costs and benefits by placing the 'benefit' of worker health above all other considerations save that of making 'attainment' of this 'benefit' unachievable. Any standard based on a balancing of costs and benefits by the Secretary that strikes a different balance than that struck by Congress would be inconsistent with the command set forth in Section 6(b)(5). Thus, cost-benefit analysis by OSHA is not required by the status because feasibility is."[63]

Thus, the Supreme Court decision places priority on worker health in the case of hazard from toxic substances and harmful physical agents. The industry supported concept of cost-benefit analysis for OSHA regulations has been dealt a blow. Perhaps now the concept of significant risk will assume more importance than cost-benefit analysis.

Summary

On the basis of the review of symptoms of respiratory disease and the history of growing awareness and recognition of ailments associated with the manufacture of cotton, it must be concluded that recognition of byssinosis in the United Statescame very late. In the

American South byssinosis existed in an industry and within a social framework which helped to retard the acceptance of byssinosis as an undesireable but controllable disease. The symptoms were recognized as early as 1832; byssinosis was ruled a compensatory disease in England in 1940. As late as the 1960's United States medical opinion still declared the disease non-existant in American textile mills. In 1970, the scientific community showed that the problem of respiratory disease peculiar to the cotton industry existed in the United States. Mobilization of public opinion, changes in social attitudes, the new scientific evidence, the enactment of the Occupational Safety and Health Act, and inputs from groups such as the Carolina Brown Lung Association and the Amalgamated Clothing and Textile Workers Union led to the setting of a new and stringent standard in the cotton textile industry to control and eradicate byssinosis.

Ironically, after decades of society coming to terms with byssinosis as an occupational disease, implementation of a national standard for control and prevention of the disease has been caught up in a new deate of benefit-risk consideration. Social factors were previously responsible for inaction. Today inaction also reflects competing needs in an inflationary, resource scarce national economy. Consensus finally exists with respect to definition, extent and measures for prevention of byssinosis. Allocation of resources may have to await unequivocal demonstration that the benefits which will accure from control will exceed the costs of control. Economic factors have become major, identifiable inputs into our social and health policy decisions.

TABLE VI

Surveys of Cotton Workers' Health
1827 - 1946

Investigator	Year	Country	Finding
Gerspach	1827	France	Beaters and pickers work 15–16 hours per day in thick dust. Cough and expectoration of blood. Many cases designated as tracheal phthisis.
Thackrah	1832	England	Fifteen hundred employees in Manchester mill—found children in carding and preparing room puny, frequent catarrh and mucous cough, mild disorders of nervous and digestive systems, found occasional bronchitis and pulmonary maladies.
Villermé	1840	France	Studied economic and social factors affecting workers. Cotton beaters, first affected by dryness of mouth, then progressive cough, slow and serious chest disease. Illness could be alleviated by removal from workroom. The disease resembled pulmonary phthisis.
Mareska & Heyman	1845	Belgium	Batter picker and beater-opener room most unhealthy. Pulmonary affections among cardroom workers most prevalent—phthisis, laryngitis also prevalent. Workers complained dust inconvenienced them most on Mondays and Tuesdays.
Bretow	1851	Russia	Large number of workers suffered from pulmonary tuberculosis.
Schuler	1872	Switzerland	Dust present particularly in air of cardroom, also in spinning and weaving rooms. Skin diseases especially eczema and varicose veins. Chronic pneumonia, emphysema, asthma, and blennorrhea prevalent.
Erisman	1887 1888	Russia	Prolonged work in factory harmful to growth and development.
Verhaeghe	1906	France	Eight hundred forty-five male and female workers. Twenty-eight percent of 1,849 cotton, wool and tow workers reported chronic bronchitis. Those with longer occupational histories more often affected.
Fioretti	1906	Italy	Dust considered as cause of illness (180 men and 630 women). Ten percent of workers had chlorosis, bronchitis, pleurisy and pneumonia in 21.2% of men and 8.6% of women.
Collis	1909	England	Strippers and grinders employed in cardrooms of 31 mills in Blackburn (126 men). After years of work, strippers and grinders develop progressive respiratory distress. Complaints of chest tightness. Symptoms more severe on Monday. Emphysema of varying degree. Of 126 men examined, 73.81% affected.
Preis	1912	Russia	Sick benefit records analyzed for approximately 5,700 male and female spinners and weavers (1905–1909). Tuberculosis, alcoholism, diseases of cochlea, or rare infection of inner ear noted.
Safford	1916	United States	Six hundred ninety-one boys under 18. Average weight, height and chest size of boys reported below average for other groups of boys. Some dulling of hearing, functional disorders of the heart. There were no conditions of the eyes, nose, mouth, teeth, tongue, lungs, skin, or digestive tract which could not be attributed to causes other than occupational.
Schmidt	1924	Germany	Four hundred forty-nine people 25–55 years old, cotton spinners, farmers and their dependents, students. Spinning factory workers inhaled dust. Cotton dust considered to be pathogenic

Investigator	Year	Country	Findings
			factors causing catarrh of upper respiratory tract. Roentgenologically, persons active in spinning factories for decades showed visible large and moderate sized bronchi as signs of mucosal proliferation and thickening of the walls in conditions of chronic irritation. Presence of pneumoconiosis not established.
Schilling	1925	Germany	Three hundred spinners and 150 agricultural workers. X-rays, some autopsies. Constant exposure to cotton dust. All spinners had history of frequent pharyngeal catarrh and bronchitis. In workers with over a decade of experience bronchitis occurred with more or less emphysema. Concluded inhalation of cotton dust resulted only in a heightened disposition to acute and chronic bronchitis and consequently an early emphysema of the lung. No heightened disposition to tuberculosis (used X-ray).
Bekritsky	1927	Russia	Four hundred workers in carding and combing rooms with dust concentrations of 14.2 mg per cu meter of air. Dust in slubbing and scutching rooms. In rooms with much dust 60% of workers had atrophic rhinopharyngitis, 24% had atrophic laryngitis. No mention of pulmonary disease.
Socolow	1928	Russia	Seven hundred fifty-eight workers, judged health of workers, one visit. Morbid alterations considered as probably due to the profession. Found diseases of respiratory tract, particularly nose and pharynx.
Report, Chief Inspector of Factories	1927	England	One thousand eleven workers inspected for deafness.
Bianchi	1932	Italy	Twenty-six hundred workers, 900 in cotton manufacture, the rest jute and hemp. Three hundred twenty of all examined had respiratory affections.
Caso	1932	Italy	Six hundred workers, age 15–65 years, workers in a spinning mill. Sixty percent of women carding, spinning and weaving department dusty atmosphere. Cardroom workers had conjunctivitis and blepharitis. One hundred workers had disturbances of respiratory tract. Fifty workers age 15–56 complained of dryness of throat, difficulty in swallowing, sneezing and mucoid rhinitis. Improvement occurred on removal from work. Twenty persons who worked 5–10 years showed evidence of chronic pulmonary pathology not easily classified clinically.
Bokser and Ryzbova	1932	Russia	Three hundred twenty-four workers—control group. Eighty-two men, none having worked in a dusty occupation. Study included determination of dust exposures. Group with 10–20 years experience complained of shortness of breath, either at rest or with slight exertion. Persons 45–50 years old evidence of emphysema and reduction of chest expansion.
Koelsch	1932	Germany	Thirteen men and 21 women cotton workers: 61.76% 20–40 years old, 75% worked more than 10 years most for 10–25 years. Indications of cardiac hypertrophy in 13 of 34. Also found bronchitis and emphysema.
Rept. of Dept. Committee	1932	England	Government inquiry into diseases of cardroom workers. Evidence of problem of respiratory disease among card strippers and grinders.

F
5-0

Investigator	Year	Country	Finding
Cano	1932	Spain	Cotton and woolen factories. Much dust produced in all operations. Affectations of respiratory tract, exclusive of tuberculosis, greater than normal average. Mortality from tuberculosis increased and mortality from heart disease took second place.
Koelsch	1933	Germany	Twenty-seven men, 48 women: 87% had over 10 years in the cotton industry, some as long as 45 years. Seventeen men and 25 women complained of chest difficulties. All beaters and carders complained of temporary asthmatic pain in throat and chest on Mondays; pains disappear by Thursday. Thirty-four of 75 had heart enlargement.
Britton et al: Bloomfield and Dreessen	1933	United States	Males in one cotton plant: 749 weavers, 435 carding, 441 spinning. Dust determinations made. Carding, spooler, and picker.
Klionskii and Yapolskii	1934	Russia	Eighteen males, 93 females—all worked in dusty atmospheres: 82% complained of cough, 70% of shortness of breath, 17% history of hemoptysis, 57% bronchitis, 38% of cardiac hypertrophy. It was concluded that textile dust does not provoke the classical pneumoconiosis.
Beintker	1934	Germany	Reports 27 cases of respiratory disease in textile mills of Westphalia.
Preuznitz	1934	England	Attempt to determine cause of respiratory disease among cardroom workers.
Chilla	1934	Italy	Investigation of health and sanitation of approximately 3,000 workers. Dust in opening, mixing and beating rooms. Laryngitis, pharyngitis and tonsillitis among workers—a few with bronchopulmonary affections.
Thiry	1938 1939	Belgium	One hundred twenty-five workers in a cotton spinning mill. Dust especially heavy in mixing and beating rooms, less dust at the cards. Twenty-four workers at [illegible], 6 at mill for a few months, others 10 years. Those working a few months and 1 working 8 years had normal X-rays. 10 or more years, 2 had normal lungs, 8 had pulmonary sclerosis with emphysema, 2 had chronic bronchitis and 2 had pachypleuritis.
Trier	1938	Denmark	Two hundred sixty-two cotton workers, 81 in spinning, 181 bale breaking.
Thiry	1940	Belgium	Three hundred one workers. 80 in preparatory processes, 221 in spinning. Former exposed to more dust. Cervico axillary adenitis in 74% of workers in preparation. Fifty-eight percent of spinners hypertensive. Respiratory capacity of many workers classified as weak or very weak. Six cases of bronchitis, 2 of asthma, 5 of tonsillitis, 1 endocarditis and 2 exophthalmic goiter.
Smith	1942	United States	One hundred fifty-six men and women in cotton batting. Chest x-rays, 51 men and 21 women physical exams. Cotton dust flew freely about and reached high concentration. Chest x-rays revealed 1 cardiovascular disease, 2 lung conditions unrelated to dust and 1 possible case of tuberculosis. Physical exams revealed varying degrees of upper respiratory infection, 2 with basal rales in lungs and 2 had diminished breath sounds.
Forero and Thomas	1943	Chile	Two hundred eighty-two textile factories (cotton, silk, rayon, etc.) approximately 4,770 workers. Hygienic conditions and

51

Investigator	Year	Country	Finding
			protective devices deficient in most factories. Byssinosis, chronic laryngeal tracheitis, chronic bronchitis stated to be present.
Ritter and Nussbaum	1945	United States	Twelve males age 37–70 with asthma—precipitated by exposure to cotton dust given physical exams and x-rays. Twenty-six persons who worked more than 30 years in carding or picking in textile mills or lint rooms and seed storage bins of cotton mills. "No evidence was found in a cross section study of the Mississippi cotton industry to support the existence of byssinosis as a clinical entity arising among employees exposed to upland cotton."
Roman	1946	Canada	Based conclusions on life histories of 205 textile industry employees (executives, office men, cotton sorters, spinners, weavers, dyers, bleachers, nappers, mechanics, painters and carpenters). Conclusions, "The author considers that there is no industry with less hazard and less occupational disease than the cotton textile industry; tuberculosis, bronchitis, and asthma formerly associated with the industry have been eliminated by means of improved lighting, scientific humidification and better ventilation with regard to clean dust free air."

*Table from material in Caminita, 1947 pp 12-23.

V. CARPAL TUNNEL SYNDROME

Although the disease carpal tunnel syndrome has been known for over a century, it has only recently been identified as a significant occupational disease that affects large groups of people. A number of reasons can be given for the length of time it took to associate carpal tunnel syndrome with occupation. They include: (1) Emphasis had been placed upon personal factors as causes for the diseases, i.e. the concentration on personal factors as causation led to overlooking occupational risks. (2) Most of the early literature stressed the belief that middle aged women were more apt to have the disease than men or younger women.[69] For example, the disease was reported to occur between two and ten times as frequently in women as in men.[70] (3) Other non-occupational factors linked to carpal tunnel syndrome included, maligned fractures, chronic trauma, rheumatoid arthritis, Paget's disease of the bone, neoplasms, neuromas of the median nerve, gout, myxedema, amyloidosis, multiple myeloma, acromegaly, pregnancy, diabetes, mellitus, Reynaud's disease, use of oral contraceptives, hormonal changes in women during pregnancy and menopause and hysterectomy with bilateral oophorectomy.[71] (4) Difficulty in diagnosing the disease. (5) Much of the early literature was concerned with treatment rather than prevention of carpal tunnel syndrome.

Description of the Disease

Carpal tunnel syndrom is considered to be one of the most common extrapment syndromes.[72,73] The carpal tunnel is in the palm of the hand and it is the channel through which passes a nerve (the median nerve) and ten tendons. In simple carpal tunnel syndrome there is no inflamed tissue inside the tunnel, just an increased pressure due to fluid and connective tissue thickening. The condition usually occurs in both hands and is usually worse at night. In tenosynovitis of the tendons at the wrist, the inflamed tendon sheaths in the carpal tunnel cause increased pressure on the median nerve, leading to the much more serious condition of secondary carpal tunnel syndrome.[74] The disease was described in 1960 in the following manner in the British Medical Journal. "The carpal tunnel syndrome consists of paroxysomal paraesthesiae, pain and subjective numbness in one or both hands, often accompanied by some objective impairment of sensation in the digits supplied by the median nerve, and by muscular weakness and wasting of the thenar eminence. It affects women predominantly, and untreated it usually pursues a variable course, with exacerbations and remissions for years. Paroxysms occur most commonly in the night and are often of such frequency and severity that the sufferer can get little sleep for weeks on end. By day symptoms may be induced by use of the hands, and many patients have to give up much of their ordinary domestic operations. Thus, this syndrome can be a source of great distress and disability to those affected by it."[75] Zenz described the disease in the textbook Occupational Medicine as a ". . . compressive neuropathy of the median nerve at the volar carpal ligament in the wrist and may be the result of a tenosynovitis involving the flexor tendons that pass beneath the volar carpal ligament. In addition to these causes which may have some relationship to occupation there are several other causes that are well to keep in mind such as the connective tissue diseases (rheumatoid arthritis, systemic lupus, erythematosus), acromegaly, pregnancy, a postiive association with the taking of hormones, hypothyroidism, etc."[76]

This description of carpal tunnel syndrome places only slight emphasis upon the relationship of occupation to the disease. (Note the phrase, "may have some relationship to occupation."

Medical Observations of Carpal Tunnel Syndrome

A number of observations of carpal tunnel syndrome can be found in the medical literature starting with the description of symtpoms of carpal tuunel syndrome by Sir James Paget in 1854.[77] Emphasis in all the early literature is on treatment. Either medical or surgical cures are suggested.

Table VII indicates early contributors to the medical literature on carpal tunnel syndrome, from 1911 to 1947.

The reports of Kramer, Garland and Healthfield in the 1950's revealed that diagnosis of the disease was being made with increasing frequency,[81] and by 1959 carpal tunnel syndrome was described as ". . the median-nerve distribution, developing progressively in the form of paroxysomal and usually nocturnal bouts of burning, aching, discomfort, partially relieved by prolonged inactivity and completely relieved by division of the transverse carpal ligament."[82]

Carpal tunnel syndrome had been established as a clinical entity and it had been demonstrated that symptoms were produced by compression of the median nerve as it courses through the carpal tunnel. However, there was no unanimity of opinion as to its pathogenesis. Evidence seemed to support the hypothesis that some physiological change, for example, menopause could render the nerve susceptible to compression. There was some agreement that symptoms were often produced or aggravated by a sudden increase in manual activity.

In 1972 Phalen reported on his long experience with carpal tunnel syndrome. At that time he stated that: 1) Carpal tunnel syndrome was the most common and most important of all nerve entrapment syndromes. 2) A patient with numbness or tingling in the fingers, or weakness or atrophy of thenar muscles must be considered to have carpal tunnel syndrome. 3) Women are more apt to have this condition than men (a ratio of 3:1). 4) It is a disease of middle age. 5) Fibrosis or thickening of the flexor synovialis within the carpal tunnel is the most common cause and must be associated with some type of rheumatic process in a majority of patients. 6) Thickening of the flexor synovialis may be caused by prolonged forceful grasping movements, and carpal tunnel syndrome may result. Under these conditions, (i.e. number 6 carpal tunnel syndrome could be classified as an occupational disease, but this is an exceedingly rare cause of median nerve compression. 7) Occupational trauma is seldom the initiating factor in production of the syndrome.[83] Phalen also described both medical and surgical treatment.

TABLE VII[78,79,80]

Contributions to Medical Literature on Carpal Tunnel Syndrome
1911-1947

Year	Contributor	
1911	Hunt	Drew attention to syndrome
1912	Marie & Foix	Reported examplex of carpal tunnel syndrome
1920	Brouwer	Reported 14 cases (emphasized occupation)
1922	Lewis & Miller	Reported a case of tardy median palsy
1926	Harris	Described wasting of thenor muscles
1930	Winckler	Reported 1 case
1931	Dorndorf	Reported 16 cases
1933	Abbott & Saunders	Brought attention to injury of median nerve associated with a fracture
1938	Moersch	Reported 1 case
1939	Wartenberg	Reported 7 cases - included an anatomical report
1941	Waltman	Reported 2 cases
1946	Cannan & Love	Established carpal tunnel syndrome as a definite entity caused by compression of median nerve within the carpal tunnel
1947	Brain & Wilkinson	Established carpal tunnel syndrome as a definite entity caused by compression of median-nerve within the carpal tunnel

By 1970 much was known about carpal tunnel syndrome, and the relationship to occupation, especially those jobs with repetiive tasks. Although known it was not emphasized. Unfortunately, there were and still are only a few studies of carpal tunnel syndrome as an occupational disease.

Carpal Tunnel Syndrome and Occupation

"Ergonomic theory relates the occurance of the condition to repetitive movements of the wrist, performance of tasks with the wrist in ulnar deviation and chronic exposure to low frequency vibrations."[84] Assembly line workers, garment workers, poultry workers, workers who's tasks include use of vibratory tools such as buffing and grinding are all exposed to cumulative trauma, a cause of carpal tunnel syndrome. The number of workers at risk is unknown because records of exposure are often not kept and many people do not even suspect that there is a causual relationship between carpal tunnel syndrome and the work they perform. We have only recently begun to define the disease as an occuaptional one. The medical literature provides minimal information on the prevalence or incidence of carpal tunnel syndrome among various occupations. Workmen's compensation records do not even include carpal tunnel syndrome. Because it is difficult to prove that the disease is work related, it is therefore also unusual to receive compensation for the disease.

Thus, the exact incidence and rate of carpal tunnel syndrome in industry has not yet been determined although the recent studies assessing the extent of carpal tunnel syndrome in some American industries indicates that it is more prevalent than previously believed.

In 1981 the National Institute of Occupational Safety and Health reported that some twenty million workers on assembly lines and other jobs requiring repetitive strain producing motion were subject to "wear and tear" injuries, and that cummulative insults could result in debilitating disorders such as carpal tunnel syndrome, ganglion cysts and tenosynovitis. NIOSH also noted that about 23,000 cases of related disorders and over 250,000 associated lost workdays were reported annually to the Department of Labor even though awareness of the occupational relatedness of chronic trauma and such debilitating diseases as carpal tunnel syndrome was very low.[85]

Some recent studies of carpal tunnel syndrome have yielded information about the disease and occupation. Wisseman and Badger found 104 OSHA-reportable disorders in a study of related disorders. They included 2 cases of carpal tunnel syndrome, 84 cases of tendonitis, 10 cases of gangleonic cysts, 2 cases of epicondylitis, 4 cases of bursitis, 1 case of myositis and 1 case of thoracic outlet syndrome from 1972 to 1976 in a photographics plant. Their study of the plant indicated that the relative risk of developing repetitive trauma disorder was greater in "problem departments." Their risk comparison provided an indication that there was something distinctive about either the tasks performed or the population in work areas. They calculated that risk attributed to gender is significantly smaller than that attributed to performing certain tasks."[86]

A study performed by Cannon, Bernacki and Walter conducted at four Pratt and Whitney Aircraft Company plants indicated that the use of vibratory hand tools and a history of gynecological surgery were assocaited with the onset of carpal tunnel syndrome. Repetitive motion tasks involving the wrist were also found to be associated with the syndromes but not as strongly associated with the onset as use of vibratory hand tools. Environmental and personal factors were identified as disease precursors, i.e. use of hand tools and bilateral oophorsectomy, stimulated manifestations of carpal tunnel syndrome over a short period of time.[87]

Armstrong and Chaffin addressed the question, Why do some persons develop occupational carpal tunnel syndrome while others do not? They noted that the disproportionate incidence of carpal tunnel syndrome in the female population suggest that hand and wrist size might be a factor, or perhaps some persons use work methods that stress the wrist tissues more than others. Subjects were employed in jobs consisting of production sewing of seat covers from heavy fabrics with commercial sewing machines. Work required grasping, and tugging on fabrics to align them as they were fed through the machine. Production rates varied. The work was repetitive and workers were on an incentive program to quickly complete their quotas. Armstrong and Chaffin found no association between hand size or shape and carpal tunnel syndrome. They found that diseased subjects tended to use a wrist position that deviated from the straight position more than those without disease did, and that the diseased subjects tended to exert greater hand forces on all wrist positions than did non-diseased subjects. Armstrong and Chaffin stated that the investigation supported the conclusion that given work methods are factors of occupational carpal tunnel syndrome.[88] Other occupational groups have been studied including dentists, construction workers, and auto upholstery plant workers.

It is clear that the studies referred to have begun to identify cases of carpal tunel syndrome in the workplace and to associate these cases with work performed. Nevertheless carpal tunnel syndrome is still under reported because it has not yet been associated with the job by many workers. Other reasons may also include the fact that some workers fear loss of their jobs or may see a personal physician who does not relate carpal tunnel syndrome to the work performed. In prevention ergomonic principles appear to be relied on almost exclusively.

Summary

The significance of the history of carpal tunnel syndrome is that a disease once considered to be caused almost exclusively by personal factors is now being reevaluated in the light of new information. There has been a change of focus from personal factors to workplace factors. Emphasis once placed almost entirely on treatment is now also placed on prevention.

Increased awareness of carpal tunnel syndrome as an occupational disease had led to efforts to prevent it in some industries. Unions representing workers in the auto, garment, meat processing, furniture, food retailing and other industries are alerting their members to the problem of carpal tunnel syndrome through educational efforts and by seeking compensation benefits for victims of the disease.[89]

Public attention has been focused upon occupational carpal tunnel syndrome. Perhaps that is the most important step toward control and prevention of industrial carpal tunnel syndrome.

VI. IN SUMMARY

There is a lesson to be learned from the history of response to workplace health risks. It is clear that approaches to the definition, recognition and control of occupational disease historically have been related to technology and science, i.e. improved methods of detection and control, better diagnostic techniques, improved epidemiological methodology and better understanding of disease, as well as to changes in social attitudes, i.e. social response to disease, changed perception of disease, and assumption of responsibility by government, labor and management for occupational health. We no longer accept dangerous and unhealthy work conditions as a necessary outgrowth of industrial expansion. Definitions of occupational disease, when arranged chronologically present a picture of expansion and extension of an earlier concept of obvious hazards.

We are constantly redefining industrial disease and risk of disease. Although the idea of assessing risk is not new and can be traced back to ancient times; the modern concept of risk is now moving toward utilization of a more analytical framework to assess risk.

The uncertainties and complexity involved in identifying and assessing work related disease, rapid proliferation of new hazards, better ability to quantitate, the increased role of regulation, interest generated by new laws, the press, and labor have placed occuaptional health in the public eye and focused upon occupational health policy decisions. Current controversy about occupational safety and health focuses upon selection of priorities for those hazards which will be controlled and the associated degree of control.

We now know that control of occupational hazards is an exercise in sorting out the risks associated with a particular agent or situation at work. Today the suggested national approach to priority selection is risk assessment. Decisions are made within both a social and scientific framework. Addressing risk therefore involves two extremely different kinds of activity. Measuring risk, for example, involves measuring the probability and severity of harm. It is an empirical, scientific activity and implies objectivity. Judging risk, for example, judging the acceptability of risk is a normative political activity and implies social value. Thus, "a thing is safe if its attendant risks are judged to be acceptable."[90]

Since Lowrance defined and analyzed risk in the 1970's we have been developing and refining definitions of risk endeavoring to create a framework for decision making. It has been suggested that we should now make a further distinction between risk assessment and risk management. Thus, a recent National Academy of Sciences study suggests that risk assessment and the choice of regulating options be distinguished, i.e. ". . . the scientific findings and policy judgments embodied in risk assessment should be explicitly distinguished from the political, economic and technical considerations that influence the design and choice of regulatory strategies."[91]

REFERENCES

1. Thrush, P.W., ed.: A Dictionary of Mining, Mineral and Related Terms. U.S. Department of Interior, (1968), p. 102.
2. Hunter, D.: The Diseases of Occupations. Little Brown and Co., Boston, (1969), p. 961.
3. Encyclopedia Britannica. 15th Edition, (1977), p. 751.
4. U.S. Department of Labor: An Interim Report to Congress on Occupational Diseases. Government Printing Office, Washington, D.C., (1980), p. 20.
5. Hunter, D.: Op. Cit., p. 959.
6. a) Pearson, G.: "On the Coloring Matter of the Black Bronchial Glands of the Black Spots of the Lungs." Philos. Trans. Royal Soc. 103:159, (1813).
    b) Gregory, J.C.: "Case of Peculiar Black Infiltration of the Whole Lungs, Resembling Melanosis." Edin. Med. and Surg. J. 36:389, (1831).
    c) Thompson, W.: "On Black Expectoration and the Deposition of Black Matter on the Lungs." Med. Chnur. Trans. 20:230-231, (1837).
7. Thackrah, C.T.: The Effects of the Principal Arts, Trades and Professions, and the Civic States and Habits of Living on Health and Longevity. Longman's, London, (1831).
8. Teleky, L.: History of Factory and Mine Hygiene. Columbia University Press, New York, (1948), p. 203.
9. Hearings Before a Subcommittee of the Committee on Labor: House of Representatives. 74th Congress, H.J. Res. 449, U.S. Government Printing Office, Washington, D.C., (1936).
10. Hearings. Op. Cit., p. 4.
11. Hearings. Op. Cit., pp. 201-202.
12. Legge, T.M. and K.W. Goadby: Lead Poisoning and Absorption Longmans, Green, and Co., New York, (1912), p. 62.
13. Hunter. Op. Cit., pp. 235-242.
14. Agricola, G.: De Re Metallica. Translated by H.C. Hoover and L.H. Hoover. Dover, New York, (1950), p. 5.

15. Rosen, G.: The History of Miners' Disease. Schumans, New York. (1943), pp. 67-70.

16. Rosen. Op. Cit., p. 98.

17. Rosen. Op. Cit., p. 99.

18. Ramazzini, B.: Diseases of Workers. Hafner Publishing Co., New York, (1964), p. 53.

19. Semmes, T.: An Essay on the Effects of Lead. Carr and Smith, Philadelphia, (1801), pp. 12-13.

20. Kober, G.M., and E. Hayhurst: Industrial Health. Blackistons Sons & Co., Philadelphia, (1924), p. 413.

21. Patty, F.: Industrial Hygiene and Toxicology. Interscience Publications, New York, (1962), pp. 953-961.

22. National Academy of Sciences: Lead, Airborne Lead in Perspective. Washington, D.C., (1972).

23. National Academy of Sciences: Lead in the Human Environment. Washington, D.C., (1980).

24. U.S. Department of Labor. Op. Cit., p. 17.

25. Thackrah. Op. Cit., pp. 147-148.

26. Ware, N.: The Industrial Worker, 1840-1860. Quadrangle Paperbacks, Chicago, (1964), p. 98.

27. Josephson, H.: Golden Threads. Duell, Sloan and Pearce. New York, (1949), p. 257.

28. Walkowitz, D.J.: Worker City, Company Town. University of Illinois Press, Urbana, (1978), p. 109.

29. Wright, C.D.: Fall River, Lowell and Lawrence: From the Thirteenth Annual Report of the Massachusetts Bureau of Statistics of Labor. Rand, Avery and Co., Boston, (1882), p. 32.

30. Leach, J.: "Surat Cotton As It Bodily Affects Operatives in Cotton Mills." Lancet, Dec. 5, 1863, pp. 648-649.

31. Caminita, G.H., W.F. Baum, P.A. Neal and R. Schnecter: A Review of the Literature Relating to Affections of the Respiratory Tract in Individuals Exposed to Cotton Dust. Public Health Bulletin No. 297. Federal Security Agency, U.S. Public Health Service, (1947), pp. 13-25.

32. Criteria for a Recommended Standard, Occupational Exposure to Cotton Dust. U.S. Dept. of Health, Education and Welfare, NIOSH,

265

Publication No. 71-118, (1974), p. 23.

33. Hill, A.B.: *Sickness Amongst Operatives in Lancashire Cotton Spinning Mills*. Medical Research Council, Industrial Board. His Majesty's Stationery Office, London, (1930), pp. 76-79.

34. Oliver, T.: *Diseases of Occupation*. E.P. Dutton & Co., New York, (1908), p. 247.

35. *Hearings Before a Subcommittee of Labor of the Committee on Labor and Public Welfare*. U.S. Senate, 91st Congress S2193 & S2788. U.S. Government Printing Office, Washington, D.C., (1970), pp. 983-984.

36. *Criteria for a Recommended Standard*. Op. Cit., p. 12.

37. Pope, L.: *Millhands and Preachers*. Yale University Press, New Haven, (1942), p. 12.

38. Pope. Op. Cit., p. 11.

39. Pope. Op. Cit., p. 29.

40. Tippet, T.: *When Southern Labor Stirs*. Jonathan Cape and Harrison Smith, New York, (1931), p. 29.

41. *Hearings Before a Senate Subcommittee on Labor*. Op. Cit., pp. 566-567.

42. Conway, M.: *Rise Gonna Rise*. Anchor Press, Garden City, New York, (1979), p. 136.

43. *American Textile Reporter*. July 10, 1969.

44. Fraser, D.A. and M.C. Battigelli, Ed.: *Transactions of the National Conference on Cotton Dust and Health*. Carolina, Chapel Hill, North Carolina, (1970), p. 90.

45. Bloomfield, J.J. and W.E. Dressen: "Exposure to Dust in a Textile Plant." *The Health of Workers in Dusty Trades*. P.H. Bull. No. 208, U.S. Treasury, Dept. Public Health Service, Washington, D.C., (1933), p. 21.

46. Drinker, P. and T. Hatch: *Industrial Dust*. McGraw-Hill, Boston, (1954), p. 75.

47. *Criteria for a Recommended Standard. . . Occupational Exposure to Cotton Dust*. Op. Cit., p. 13.

48. McKerrow, C.B. and R.S.F. Schilling: "Pilot Inquiry into Byssinosis in Two Cotton Mills in the United States." JAMA 177: 850-853, (1969).

49. Bouhuys, A.L., L.J. Heaphy, R.S.F. Schilling and J.W. Welborn: "Byssinosis in the United States." *N. E. Jr. Med.* July 27, 1967, p. 171.

50. Zuskin, E., R.L. Wolfson, G. Harpel, J.W. Welborn and A. Bouhuys: "Byssinosis in Carding and Spinning Workers." *Arch. Envir. Health.* Nov., 1969, p. 666.

51. Davies, C.N. Ed.: *Inhaled Particles and Vapors II.* Pergamon Press, Oxford, (1967), pp. 69-74.

52. Zuskin, et al. *Arch. Envir. Health.* Op. Cit., p. 671.

53. Fraser, D.A. and M.C. Battigelli, Ed. Op. Cit., p. IV.

54. *Hearings Before a Subcommittee on Labor.* Op. Cit., p. 698.

55. *Hearings Before a Subcommittee on Labor.* Op. Cit., p. 587.

56. *Hearings Before a Subcommittee on Labor.* Op. Cit., p. 1004.

57. *Hearings Before a Subcommittee on Labor.* Op. Cit., p. 1006.

58. Federal Register. *Occupational Exposure to Cotton Dust.* Dept. Labor, OSHA.

59. Federal Register. Op. Cit., p. 37352.

60. Federal Register. Op. Cit., p. 37355.

61. *Objections and Arguments of American Textile Manufacturer's Institute, Inc.* Exhibit 121, Proceedings of Informal Public Hearings on Proposed Standard for Exposure to Cotton Dust. (1977).

62. *Objections and Arguments.* Op. Cit., p. 3.

63. *Objections and Arguments.* Op. Cit., p. 8.

64. *Objections and Arguments.* Op. Cit., p. 57.

65. *Statements of Robert D. Soule.* Vice President, Director of Industrial Hygiene Services for Clayton Environmental Consultants, Inc. Presented at Dept. of Labor Hearings on Cotton Dust Occupatinal Exposure Standard. Exhibit No. 17, (1977), pp. 7-8.

66. Comment of the Council on Wage and Price Stability before the Occupational Safety and Health Administration. Docket No. H-052, p. 37.

67. Federal Register. Op. Cit., p. 27379.

68. *New York Times.* June 18, 1981.

69. Phalen, G.S.: "The Carpal Tunnel Syndrome." *Clinical Orthopedics and Related Research.* March-April, 1972, p. 29.

70. Armstrong, T.J. and D.B. Chaffin: "Carpal Tunnel Syndrome and Selected Personal Attributes." J.O.M., July, 1979, p. 481.

71. Cannon, L.J., E.J. Bernacki, and S.D. Walter: "Personal and Occupational Factors Associated with Carpal Tunnel Syndrome." J.O.M., April, 1981, p. 255.

72. Bernard, M.L.: "Carpal Tunnel Syndrome: Identification and Control." Occupational Health Nursing, June 1979, p. 15.

73. Phalen. Op. Cit., p. 29.

74. Health and Safety Bulletin - ACTU/VTHC Occupational Health and Safety Unit. Australia, (1982), p. 5.

75. Crow, R.S.: "Treatment of the Carpal Tunnel Syndrome." Brit. Med. J., May 28, 1960, p. 1611.

76. Zenz, C.: Occupational Medicine. Yearbook Medical Publishers, Chicago, (1975), p. 253.

77. Das, S.K. and H.G. Brown: "In Search of Complications in Carpal Tunnel Decompression." The Hand, (1976), p. 243.

78. Brain, W.R. and A.D. Wright: "Spontaneous Compression of Both Median Nerves in the Carpal Tunnel." Lancet, March 8, 1947, p. 277.

79. Cannon, B.W. and J.C. Love: "Tardy Median Palsy; Median Neuritis; Median Thenar Neuritis Amenable to Surgery." Surgery, 1946, p. 210.

80. Crow. Op. Cit., pp. 1611-1612.

81. Ibid.

82. Tanzer, R.C.: "The Carpal Tunnel Syndrome." J. of Bone and Joint Surgery, June, 1959, p. 626.

83. Phalen. Op. Cit.

84. Cannon, L.J., et al.: Op. Cit., p. 255.

85. Occupational Safety and Health. August, 1981, p. 12.

86. Armstrong, T.J.: "Carpal Tunnel Syndrome and the Female Worker." Paper presented at 21st Annual American Industrial Hygiene Conference. May, 1982, p. 29.

87. Cannon, L.J., et al.: Op. Cit., p. 255-258.

88. Armstrong, T.J. and D.B. Chaffin: Op. Cit., pp. 481-486.

89. Wall Street Journal. January 14, 1983.

90. Lowrance, W.W.: Of Acceptable Risk. William Kaufman, Inc. Los

Altos, Ca., (1976), p. 8.

91. National Research Council: *Risk Assessment in the Federal Government: Managing the Process*. National Academy Press, Washington, D.C., (1983), p. 7.

A History of Occupational Safety and Health in the United States

Office of Technology
Assessment,
Contract 333-4260.1

Marthe Beckett Kent
12 April 1983

A HISTORY OF OCCUPATIONAL SAFETY AND HEALTH IN THE UNITED STATES

Since the last quarter of the 19th century, Federal, state, and local governments, industry and labor, and private and professional societies have made sporadic and generally uncoordinated attempts to reduce the accident toll and protect the health of working men and women. In this period, technological advances and changing patterns of work have added new and poorly understood health hazards to the traumatic injuries and deaths typical of workplaces in mining, construction, and heavy industry: the Age of Industrialization has given way to the Age of Chemicals. A review of American efforts to control occupational hazards by legislative and voluntary means will provide a background for the assessment of control technologies that follows.

State Efforts

Concern for the well-being of workers arose during the period of rapidly expanding industrial development that followed the Civil War, when the largely rural and predominantly home-centered economy was replaced by the urban and factory-centered work environment typical of the Gilded Age. Hundreds of thousands of poorly trained men and women crowded into the sweatshops and factories of the cities, causing immense problems of sanitation, ventilation, lighting, and contagious disease. In the workplace, these threats to the public health were compounded by industrial accidents and deaths: in 1907 alone, more than 4,000 railroad workers were killed on the job (Page and O'Brien: 70). In the same year, a Bureau of Labor report estimated that as many as 17,500 workers, out of a total workforce of 26 million, were killed each year (Berman: 67).

Since few states kept accurate records of occupational injuries and fatalities before workmen's compensation laws were passed (Corn: 697), it is difficult to determine injury and fatality rates at the turn of the century with any accuracy. However, conservative estimates place these at more than twice the present rate (Berman: 67). (In Great Britain, where better records were kept, the rate in 1900-1910 was 17.5 fatalities per 100,000 workers, compared with 4.5 per 100,000 in 1961-1970.) The earliest states to enact safety legislation were those, like Massachusetts, New York, and Pennsylvania, that were heavily industrialized and densely populated.

As early as 1852, Massachusetts passed a law regulating steam engines and permitting state inspectors the "power of closure" in situations of grave hazard (Felton: 810; Policy Research Incorporated: 36). Twenty-five years later, the same state prohibited the cleaning of machinery while it was operating (an early precursor of the "lock-out" provisions found in many of today's safety standards) and hired the nation's first health inspectors (Felton: 810; Policy Research Incorporated: 36). By 1890, 22 of the states had passed regulations permitting safety inspections in mines, and 14 had factory and workshop inspectors (Ravenal: 321). However, these early laws were rarely enforced (Policy Research Incorporated: 37), partly because inspectors, who were often political appointees, were too untrained to recognize even the most obvious safety hazards (Heimann and Trasko: 943). As late as 1969, only 21 states gave safety inspectors the right to shut down a work area that presented an imminent hazard (Page and O'Brien: 72).

In occupational health, the situation on the state level was even bleaker. The earliest state health programs were organized in Connecticut, New York, and Ohio in 1913, and the first important occupational disease laws, the famous "lead laws," were passed in New Jersey, Ohio, and Pennsylvania in the same period (Policy Research Incorporated: 38; Klem and McKiever: 227). These laws, designed to protect painters and smelter workers from lead poisoning, were the culmination of more than 20 years of effort on the part of Alice Hamilton, a pioneer in occupational medicine, and others (Kaufman and MacLaury: 27). The passage in 1912 of national legislation (the Esch Act) taxing the sale of white-phosphorous-tipped matches put an end to "phossy jaw," as the fatal occupational disease of matchmakers was called. (Phossy jaw was first diagnosed in European matchworkers in 1838, and several medical articles on the subject had appeared in Belgium, France, and Germany before 1900 (Legge (1936): 422). Later, the cancer of the lower jaw occurring among the luminous watch dial painters of New Jersey was recognized as occupational in origin and outlawed. Despite these occasional successes, however, state occupational health programs had been established in only 20 states and jurisdictions by 1968 (Ashford: 50); in addition, even in states with health programs, the power to develop and enforce state health laws and to inspect worksites was often scattered among several state agencies (Heimann and Trasko: 943). This fragmentation of powers, which began with the early lead laws and continues to the present day, has contributed significantly to the ineffectiveness of many state occupational health programs. Further, the lack of uniformity in state health laws led to situations such as that with betanaphthylamine, an exceedingly powerful human carcinogen. When Pennsylvania banned the use, manufacture, storage, or handling of betanaphthylamine, another facility in another state began to produce the chemical (U.S. Congress, House Report No. 91-1291, cited in BNA: 153).

Despite the passage of hundreds of individual state occupational health and safety laws over a period of more than a century, a survey taken in 1968 showed that most states had more game wardens than safety inspectors (Page and O'Brien: 71). State expenditures on occupational safety ranged from $0.01 per employee in Wyoming to $2.70 per worker in Oregon, the state with the highest per-capita safety budget. State occupational safety programs, which were much more highly developed than occupational health programs, covered only the mining portion of the workforce in four states, and one state, Texas, had no safety legislation at all until 1967 (Page and O'Brien: 70). A 1964 study reported that, on average, there was only one occupational health staff member for every 108,000 workers (Heimann and Trasko: 946), and there were fewer than 1,600 safety inspectors in the various state programs combined (BNA: 14). There was widespread agreement that, as one historian has summarized it, "Safety and health laws, historically left to the states, were piecemeal, varied in quality, and often unenforced" (Corn: 699). A keynote speaker at a trade association meeting in Washington in 1973 pointed to another difficulty wi h state as opposed to Federal laws:

> When...[there are] a proliferation of different state plans and state enforcement...American business [has] great difficulty because most... companies...are multiproduct, multiplant companies. Having to live with...40 or 50 different

> approaches...as distinguished from a single set of rules...concerns me greatly (Machinery and Allied Products Institute: 11).

In contrast to the haphazard development and variability of most state safety laws (in 1890, for example, two states regulated the use of explosives, two required safety appliances on railroads, and 19 mandated that seats be provided for women employees) (PHS: 371), the enactment of workmen's compensation statutes in many states followed an orderly pattern and occurred within a relatively brief period of time.

Workmen's Compensation Laws

The widespread passage of state workmen's compensation laws in the first two decades of this century is a rare example in the history of occupational safety and health of a coordinated effort among industry, labor, private, and professional organizations. The concern for social welfare originated in the Progressive Era between 1890 and the First World War, and was expressed in the enactment of a variety of social measures: safety regulations, workmen's compensation, widows's benefits, and child labor laws (Castrovinci: 267). Although the Progressive spirit, fueled by the efforts of the muckraking journalists, succeeded in enlisting the support of prominent people from different classes and interests, the motivations of the various participants were quite different.

Employers supported the principle of worker's compensation because it promised to substitute a fixed system of payments, whose costs could be planned for and incorporated into other business expenses, for the prevailing system of arbitrary awards under common law. Employers found going to court unsatisfactory for many reasons: because awards favoring the injured plaintiff were increasing at the turn of the century both in number and in size; because they perceived jury awards to be related to their ability to pay rather than to the merits of the case; because liability insurance costs were increasing; and because they feared that the hostility engendered by the adversarial nature of court actions would increase the likelihood of labor unrest and industrial disruption (Berman: 74-75; Castrovinci: 270-272; Kotarba: 789).

Businessmen also feared that, without compensation laws to protect them against suit, the courts would make awards on the basis of employer infractions of safety regulations, which were being passed in record numbers (Castrovinci: 273). Further, since employers' liability premiums were set in accordance with accident rates for the employer's industrial class as a whole rather than on the basis of an employer's own accident experience, employers with good safety practices were forced to subsidize those with poorer practices. The support of such leading business associations as the National Civic Federation and the National Association of Manufacturers (NAM) was essential to the enactment of the early compensation laws (Castrovinci: 266; Weinstein: Ch. 2). Because NAM represented small employers who were unable to afford the relatively generous voluntary benefits programs of such industry giants as U.S. Steel, the Association was particularly eager to secure passage of the compensation laws (Weinstein: 47).

Labor's position, however, was not so unequivocal, for several reasons. First, labor saw as the chief impediment to achieving just compensation for industrial injuries the three common law defenses allowed employers in such cases. Under the common law, employers were only held responsible for injuries caused by negligence on the part of the employer. If it could be shown that the injured employee had himself been negligent, had knowingly and voluntarily accepted the risk associated with the work, or had been injured by the negligence of another employee, the employer was held not liable for the injury. The unions initially believed that abolishing these defenses would open the door to more and larger court awards and bigger out-of-court settlements. Labor spokesmen also expressed fears that the lower costs employers would be required to pay to insure single men would lead to the preferential hiring of unmarried men, and that any system of fixed benefits would be inadequate (Castrovinci: 282; Weinstein: 43-44). Organized labor also distrusted both the national and state governments because they had participated in anti-union and strike-breaking activities, and feared that social welfare measures would function in the U.S., as in Bismarck's Germany, to weaken workers' loyalty to their unions (Berman: 78; Weinstein: 43-44).

By 1900-1910, however, the labor unions, and particularly the fledgling American Federation of Labor, actively supported workers' compensation; most of the state compensation commissions had an equal number of labor and management representatives. The benefits of the system for working men and women were obvious: They would be assured of receiving medical payments, compensation for partial or temporary disability, and, in the event of death, family benefits for any injury arising from their employment, without regard to negligence (workers' compensation is thus the first "no-fault" insurance). In addition, all types of work-related injuries, rather than the 15 percent covered at that time by private insurance, and all workers, even those at high risk, would be covered by the new system (Castrovinci: 277). Most importantly, the 7 out of 8 injured workers who were not able to collect any damages or compensation would be provided for, at least minimally (Policy Research Incorporated: 37).

Needless to say, the private insurance companies favored compensation legislation both because they would receive the associated administrative fees and because they wanted to avoid state intervention, i.e., state-run insurance plans, and government interference, i.e. a national insurance program (Castrovinci: 274). The newly formed professional societies and private philanthropies, such as the Russell Sage Foundation, the Social Reform Club, and the American Association of Labor Legislation, supported workmen's compensation out of humanitarian concern and an interest in preserving the social equilibrium.

In the 20 years after the turn of the century, 43 states and the Federal Government passed compensation statutes (Castrovinci: 267); Mississippi, the last state to enact such a law, joined the system in 1948 (Klem and McKiever: 230). In practice, the compensation system has served to distribute the losses of occupational safety and health injuries and fatalities somewhat more fairly than the earlier common law system, but employers appear to have derived the major benefits of the system. The system has provided some incentive for large employers to improve workplace conditions, which are reflected in their experience ratings and therefore premiums, but small employers do not have this incentive. It has been estimated that employers' compensation costs have been "stabilized" at one percent of payroll (Berman: 75); these costs are so minimal because the system largely neglects occupational disease and generally ignores worker rehabilitation.

The injured employee, on the other hand, receives only an estimated 50-60 percent of his former wage, and that only in injury cases. Despite the fact that the first state occupational disease compensation law was passed in 1911 (Felton: 811), most states did not pass comparable statutes until the 1930's (Heimann and Trasko: 943), and even then the number of compensable diseases was strikingly low. In the 30's, for example, although the occupational nature of silicosis had been known in the United States for more than 20 years, only three states (Massachusetts, West Virginia, and North Carolina) allowed silicotic miners to recover under the law. In addition, since payments under this system are considered compensation for lost earnings rather than damages, employees cannot recover for "psychic" consequences, such as pain and suffering and family dislocation (Berkowitz: 46).

Improvements that have been suggested to make the system both more equitable and more effective include replacing a larger share or all of the injured worker's wage, turning the system's insurance functions over to the state to increase the size of a worker's benefit, adding a substantial deductible to worker's compensation insurance policies that the employer would be required to pay, and permitting workers to sue employers in the courts as well as to collect compensation (Berman: 79). Critics have also suggested that the compensation system has encouraged acceptance of the belief that accidents are an inevitable part of working life and has thus interfered with the search for better ways of preventing accidents and protecting workers.

Federal Efforts

In the period before the Civil War, the Federal government played a negligible role in protecting the health of its citizens, except in the case of a few specialized populations: seamen and soldiers, veterans, American Indians, Federal prisoners, and Federal employees. Several early attempts (1796, 1852) at Federal intervention in matters of public health (enforcement of maritime quarantine, state grants to establish asylums for the insane) were rebuffed by the states, which considered public health a state responsibility (Carleton: 197).

In 1798, however, the Marine Hospital Service, which later evolved into the Public Health Service, was established to provide care to seamen disabled on the job (Felton: 809). The Hospital was paid for through the first system of health insurance in this country: a tax of 20 cents annually deducted from all seamen's wages. In the early 19th century, the Marine Hospital's physicians were primarily concerned with the control of epidemic diseases, such as cholera and yellow fever (Ravenal: 2). Other Federal health activities were confined to such matters as sanitation, garbage collection, and street cleaning, activities which had occupational as well as public health impacts (Carleton: 233).

Several measures were passed on behalf of Federal employees in this period: an 1833 law granting compensation to disabled seamen, an 1868 law limiting the workday of Federal employees to 8 hours, and in 1908 and 1916, compensation acts covering Federal railroad and other employees (Felton: 810; Kotarba: 788; Policy Research Incorporated: 41). However, the government did not become seriously involved in occupational safety and health until the rapid and uncontrolled rise of industrialization in the post Civil War period focused attention on the rising toll of worker injuries and deaths. The Public Health Service (PHS), founded to "promote the protection and advancement of both the physical and mental health of the American people" became the agency principally responsible for non-mining occupational safety and health (Ravenal: 9).

Public Health Service

A statute passed in 1889 established the Commissioned Corps of the Public Health Service for physicians; commissioned status was not extended to dentists, nurses, engineers, and other health service professionals until the Second World War (Ravenal: 2). PHS medical personnel were sent as advisors to State and local governments and to Federal agencies, and their efforts were focused primarily on the prevention of contagious diseases. The Office of Industrial Health and Sanitation, which conducted epidemiological and toxicological research into occupational health hazards, was established in PHS's Division of Scientific Research in 1914, and became a division of the National Institutes of Health in 1937 (Policy Research Incorporated: 42).*

In addition to conducting its own research, the PHS played a vital role in this period in supporting the development of state industrial hygiene capability. The Social Security Act of 1935 provided funds in the form of annual grants-in-aid to the states for public health programs, and within 8 years, 38 state occupational health units were in operation (Policy Research Incorporated: 38). The PHS's Division of Industrial Hygiene provided guidance and technical assistance to personnel assigned to these state units, and often detailed PHS personnel to supplement state staff (Policy Research Incorporated: 42).

However, both Federal funding and the program emphasis within state units were sensitive to changes in national priorities. The Second World War increased the importance on industrial hygiene, which was seen as a means of conserving manpower and which also strengthened the role of the Federal government in public health in general (Heinmann and Trasko: 944). After the war, interest shifted to civil defense, radiological health, and air pollution, and many state health personnel left state service for better paying jobs in industry (Heinmann and Trasko: 944). Annual PHS funding for state industrial hygiene programs fell in the 1945 to 1955 period from $4.5 million to $0.5 million (Policy Research Incorporated: 39). By 1964, 9 states were still without occupational health programs and in most of the other state programs, the focus had shifted from occupational to environmental health.

---

*The Division of Industrial Hygiene was transferred to the Division of Occupational Health in 1960, and became the Bureau of Occupational Safety and Health (BOSH) in the late 1960's.

In addition to supporting state occupational safety and health efforts, the PHS continued to be involved in occupational health and safety directly through the Bureau of Occupational Safety and Health (BOSH). This Bureau, which had undergone many changes of name and venue (it had twice during the 1960's been shifted to Cincinnati and then back to Washington) was research oriented and almost entirely devoted to health issues (Page and O'Brien: 88-94). Its ability to carry out its mandate--to conduct studies and collect data to aid in the prevention and control of occupational injuries and illnesses--was severely hampered by the fact that BOSH personnel did not have the authority to enter workplaces to conduct evaluations and collect data. This limitation was remedied when BOSH's successor, the National Institute for Occupational Safety and Health, was established in 1970 under the OSH Act.

Other Federal Occupational Safety and Health Efforts

Many Federal programs in non-PHS agencies have also been concerned with various aspects of occupational safety and health. National attention has historically focused on several high-hazard industries, such as mining, longshoring, railroading, and construction. The history of Federal efforts to control occupational hazards in these industries has followed a consistent pattern. The coal mining industry provides a good example.

The Bureau of Mines was established in the Department of the Interior in 1910, but Bureau personnel were specifically denied "any right or authority in connection with the inspection or supervision of mines." Although the powerlessness of Bureau personnel was widely deplored, it was not until 1941 that the Federal Coal Mine Health and Safety Act, which granted inspection authority to the Bureau, was passed. An excerpt from the House of Representatives report accompanying the bill captures the sense of Congress at the time:

> Investigation reveals no common standard of safety among the States, no common regulations, and, in addition to this, a lack of uniform enforcement of such [state] regulations as are in effect....In order to supplement the work of the state agencies, the bill under consideration, extends and enlarges the authority of the Federal Bureau of Mines. It is not regulatory in any sense. It merely authorizes the Bureau, through its representatives, to make inspections of the underground workings and publicize its findings and recommendations. These inspections...are to be made in conjunction with the local State agencies so that there is no asumption of the State authority (U.S. Congress, House Report, 77th Congress, as cited in Senate Report No. 95-181:2).

Later laws gradually increased Federal authority over coal mine hazards: in 1966, Bureau inspectors were permitted to close certain establishments operated by employers guilty of repeated serious violations. Citing the Federal government's "fatalistic attitude" and failure..."to act vigorously to change [the prevailing bad practices]," the 91st Congress passed the Coal Mine Health and Safety Act of 1969 (the Coal Act) (U.S. Congress, Senate Report No. 91-411, cited in Senate Report No. 95-181:4).

Coal Act standards were mandatory, and provided for civil penalties for standards violations. The Congress shifted responsibility for enforcement of the Act from the Bureau of Mines to the Mining Enforcement and Safety Administration because, among other issues, the Interior Department had "pursued the goal of maximizing production...which was not wholly compatible with the need to interrupt production...even though, in the committee's view, over the long-run, improved health and safety promotes greater productivity through reduction of 'down-time' and improved employee morale" (U.S. Congress, Senate Report No. 95-181:5). Congress believed it necessary to separate the Bureau's research and development activities from its enforcement program to eliminate the "basic conflict" between the goals of mining safety and production demonstrated by the Bureau's enforcement record (U.S. Congress, Senate Report No. 95-181:5).

Despite the increase in authority given to the Federal Government by the 1969 Coal Act, safety and health conditions in the mines continued to be unacceptable to the Congress; approximately one of every 1,500 miners, compared with one of every 12,400 workers in general industry, were reported to have been killed in 1973 (U.S. Congress, Senate Report No. 95-181:7). In 1977, Congress passed the Federal Mine Safety and Health Act (MSH Act), the first Federal law to encompass both coal and metal mines and all safety and health matters (except training and research) in one executive department. The Department of Labor was empowered by this Act to inspect mines, and to develop, promulgate, and enforce safety and health standards applicable to mines.

Another example of Federal occupational safety and health legislation before the 1960's was the Walsh-Healey Act of 1936. This legislation covered all employees working for employers who had contracts with the Federal Government that exceeded $10,000 in total value (Ashford: 51). The McNamara-O'Hara Act of 1966 and the Construction Safety Act of 1969 extended Federal regulation to service contract employers and Federally funded construction employers, respectively. Employers were required by the terms of their contracts to comply with Walsh-Healey safety and health standards, which were recommended by the Bureau of Labor Standards (LSB) of the Department of Labor. The LSB, which was established in 1934 as the Division of Labor Standards, was also given the authority to inspect workplaces covered by Walsh-Healey, and had the power to prohibit employers who violated the Act from bidding on Federal contracts for a period of 3 years. However, the LSB almost never used its inspection and enforcement powers: in 1969, only 5 percent of the 75,000 firms covered by Walsh-Healey were inspected. At the worksites inspected, a total of 33,000 violations of LSB safety regulations were recorded, while only 34 formal complaints were issued. Only two companies were blacklisted (prohibited from bidding on Federal contracts) in 1969, and only three were similarly treated in 1968 (Page and O'Brien: 100). During the same 2 years, 29,000 workers lost their lives on the job; since Walsh-Healey affected about one-third of the workforce, an estimated 10,000 workers covered by Walsh-Healey were fatally injured in this period.

The history of events under the Walsh-Healey Act exemplifies the sporadic and ineffectual efforts of the Federal Government to control occupational hazards in the years before OSHA, and no trend toward increased government control was seen in Walsh-Healey's 35-year term. Over a longer period of time, however, a pattern of increasing Federal involvement, such as the progression that occurred in mining, can be seen; this trend was particularly apparent in the extra-hazardous trades: maritime, railroading, mining, and construction. In each case, the first laws permitted Federal inspectors to inspect specific aspects of hazardous operations, e.g., man-cages (personnel hoists) in mines, air brakes on trains, shackles and other rigging components in longshoring. This first stage was gradually followed by Federal assumption of the responsibility for developing or recommending standards, helping employers to comply with them (and only rarely, in cases of grave danger, using the power of closure), and finally, of enforcing them. In all cases, the progression to full Federal responsibility took more than half a century.

Voluntary Efforts

In addition to local, state, and Federal regulation in the area of occupational safety and health, many programs were initiated in the private sector. These involved individual companies, trade associations, organized labor, employee groups, and professional associations and societies. Many of these programs were important in developing public awareness of workplace hazards. Among the earliest voluntary organizations were the International Association of Factory Inspection (1886), the American Association of Railroad Surgeons (1888), the American Association of Labor Legislation (AALL) (1906), and the National Civic Federation (NCF) (1900). The most important of these early groups were the NCF and the AALL.

National Civic Federation

The Federation's membership consisted of big businessmen, such as Andrew Carnegie and Marcus Hanna, and labor leaders such as Samuel Gompers of the American Federation of Labor (AFL) and John Mitchell of the United Mine Workers (UMW). Public officials, such as Grover Cleveland and William Howard Taft, also belonged to the NCF. One of the Federation's most enduring contributions to professional interchange was the idea of "tripartite" representation: labor, management, and public representation on civic and government boards and committees. The NCF concerned itself chiefly with maintaining the existing social and political stability and believed that the "labor problem" was the most important social issue of the time (Weinstein: Ch. 1). The Federation actively enlisted the support of the leaders of the big labor unions, and often itself mediated labor disputes. It opposed the anti-union activities of such organizations as the National Association of Manufacturers (NAM), and supported the principle of collective bargaining, believing with Louis Brandeis that "The trade unions also stand as a strong bulwark against the great wave of socialism" (Weinstein: 17). The NCF also consistently supported workmen's compensation laws.

After 1905, the NCF emphasized "welfare" work, the name given to activities that were designed to develop a sense of identification between the worker and the employer. Large corporations such as the National Cash Register Company, U.S. Steel, and Sears Roebuck provided training for workers, low-cost housing, recreational facilities, pensions and insurance, and education in safe work practices and equipment use. However, these activities were increasingly seen as efforts to undermine organized labor, and the NCF gradually lost the support of labor, which began to turn to the political parties to achieve its goals (Weinstein: Ch. 1).

The American Association of Labor Legislation

Another socially conscious group that was influential in securing workmen's compensation legislation was the American Association of Labor Legislation (AALL), founded in 1906. Its numbers were wealthy businessmen, but, unlike the NCF, it did not attract trade-union participation (Weinstein: 48). The AALL failed to achieve uniform state compensation laws, which it believed were necessary to prevent companies from moving from states with higher premiums to those with lower rates (Berman: 72). It was successful, however, in passing the Esch Act, which taxed the deadly white-phosphorus-tipped matches, in 1912.

U.S. Steel

The best-documented of the corporate voluntary programs was that of U.S. Steel; the program was instituted in 1907 in response to the appalling toll in worker injuries and deaths in the company's plants. In one steel plant in 1906, 46 men had been killed and another 598 injured (Weinstein: 41). The company offered a Voluntary Accident Relief Plan, which paid compensation to injured workers or their widows on condition that the employee and his family agree not to bring suit against the firm. An accident prevention program that included installation of machine guards and other hardware, on-the-job training in safety, and the use of safety slogans and contests succeeded in reducing U.S. Steel's serious injury rate by 43 percent in a period of 4 years (Brody: 166). It was estimated that the company spent as much as $750,000 annually on its safety programs (Brody: 166). Many other large companies, such as American Smelting and Refining, International Harvester, and Sears Roebuck, had similar employee welfare programs.

The National Safety Council

Organized in 1912, the National Safety Council (NSC) was the first national organization devoted entirely to occupational safety. The impetus behind its formation was the rising industrial accident rate, which was also largely responsible for the drive for compensation. The Council was governed by a Board of Directors traditionally dominated by businessmen. It sought to achieve industry consensus for its recommendations, and, until recently, favored non-mandatory standards, training and education, and voluntary safety programs (Page and O'Brien: Ch 7.) as the best method of improving safety records. The NSC thus epitomizes the voluntary safety movement (Berman: 75). Although the Council has emphasized automobile and home accidents to the detriment of occupational accidents, its safety publications (and particularly Accident Facts) are well known and widely disseminated. The Council has worked extensively with the Department of Labor to provide safety training courses and materials to industry. Industrial firms that belong to the NSC have been reported to have "injury rates well below those of non-members," as are companies belonging to trade associations (BNA: 14).

Benefit Associations, Union Activity, and Collective Bargaining

Before state compensation laws had been passed, workers in large plants and factories had established a variety of voluntary societies and mutual benefit associations. These mutual insurance societies, like those of the 13th century guilds, paid a death benefit to widows of dead workers and a weekly disability payment to injured employees.

Benefit associations organized along ethnic lines were prevalent at the turn of the century in large plants, such as U.S..Steel's South Works; since the accident rate for non-English-speaking workers was double that of other workers at the same mill (Brody: 92-111), these societies were obviously badly needed. The special vulnerability of foreign-born industrial workers to injury or death in the workplace has been widely recognized (Page and O'Brien: 52; Legge (1936): 636; Hamilton: 151), and as late as 1930, race probably played a major role in the Gauley Bridge Disaster (Page and O'Brien: 61). The insurance functions of the fraternal orders, mutual benefit societies, and corporate "welfare" programs were gradually supplanted by state compensation coverage.

During the 1910 to 1930 period, union efforts to increase the power of employees were vigorously opposed by employers, who obtained court injunctions to quell labor disputes. This use of judicial power was severely limited by passage of the Norris-La Guardia Act in 1932; union organizing activity increased dramatically in the subsequent period, and the number of collective bargaining agreements rose accordingly. In 1948, the National Labor Relations Board (NLRB) ruled that health and welfare clauses were proper subjects of collective bargaining (Corn: 698); in 1966, the NLRB determined that "job safety was a mandatory subject of collective bargaining" (Ashford: 199, note). Although by 1970, 65 percent of all collective bargaining agreements were reported to contain "some type of health and safety clause" (BNA: 14), many of these clauses were no more than "boilerplate" references to safe working conditions (Page and O'Brien: 116).

By the 1960's, about one-quarter of all collective bargaining agreements included a provision for labor-management safety committees, but few of these committees were empowered to shut down work in situations of grave hazard or to demand that workplace dangers be addressed (Page and O'Brien: 118-121). In addition, the international unions generally had no safety and health professionals on their staffs even as late as 1970, and the unions were thus not in a position to recognize the hazards posed by new chemicals and new processes (Page and O'Brien: 131-136). The estimated 75 percent of the workforce not organized into unions in 1970 was without recourse even to these largely ineffective protective mechanisms. Throughout the period before the OSH Act, collective bargaining negotiations placed economic issues above all else. As one union representative said, "You can't eat safety" (Page and O'Brien: 116). Although it may be true that bargaining for job safety and health would have forced the unions to make an "awful choice: worker's lives, limbs, and health versus more pay, better insurance, more vacation days, and other traditional benefits" (Sheehan: 229), it seems clear that organized labor had not achieved any more success in the area of occupational safety and health than had other voluntary efforts.

The Standards Organizations

In 1918, a group of large and medium size corporations and trade associations formed the American National Standards Institute (ANSI)* to develop industrial safety standards by the consensus method. From the beginning, ANSI's major purpose was to develop standards the "courts would adopt as governing corporate conduct," i.e., that would provide industry some protection from liability suits (Page and O'Brien: 159).

---

*The Institute's original name was the United States of America Standards Insitute, and its standards were referred to as "USA" standards.

The membership of ANSI consists of companies (company members) and trade associations, government agencies, and private groups (member bodies). Several unions are also member bodies of the organization. The Institute develops standards through the consensus method; consensus is defined in its constitution as a position "achieved according to the judgment of a duly appointed authority. Consensus implies much more than the concept of a simple majority but not necessarily unanimity."

ANSI standards are developed by standards committees and are reviewed, since 1969, by a Board of Standards Review. The Board has nine industry members, two representatives from the Federal government, one from municipal government, two academic representatives, and one member from a consumer organization (Page and O'Brien: 159). The Board is authorized to decide when a standards committee has reached consensus; this decision includes counting and weighting the votes of the committee's members. The votes and weighting factors are not made public, although ANSI does circulate drafts to interested parties for comment throughout the final consensus process.

A large part of ANSI's financial support derives from the sale of its publications, and membership fees comprise the remaining portion of the Institute's budget. Before 1970, there was a limit to the amount any member could contribute, but the ceiling on individual donations has since been removed. Member groups with limited funds have greater difficulty than trade associations or corporate members in financing the participation of members on the technical committees, and they cannot contribute to the Institute's budget on the same scale. In addition, ANSI standards are almost exclusively devoted to safety hazards. The Institute reviews and issues more than 400 standards annually.

The principal voluntary standards organization in the area of occupational health is the American Council of Governmental Industrial Hygienists (ACGIH), founded in 1938 by a group of industrial hygienists from various levels of government. The ACGIH is a private organization whose standards are developed by a straight membership vote (BNA: 28-32). In 1968, the ACGIH adopted more than 400 Threshold Limit Values (TLV's) for hazardous substances. The TLV's are eight-hour time-weighted average values that are suggested limits for workday exposure; they are "guides for the control of health hazards," and were historically directed to the toxic, rather than carcinogenic, cytogenic, or mutagenic, properties of chemical substances. In a special appendix to the 1968 ACGIH publication, a list of carcinogens, with recommended exposure limits of zero, was published. ACGIH standards have been adopted by several foregin governments and were incorporated in 1969 as Walsh-Healey standards by the Bureau of Labor Standards.

Section 6(a) of the OSH Act permitted existing Federal standards (such as those of the Walsh-Healey and Service Contract Act) and consensus standards to be adopted as OSHA standards for a period of two years after the effective date of the Act. This provision was designed to give the agency a "head start" on standards development, and resulted in the adoption of hundreds of ANSI and National Fire Protection Association standards before the 1973 deadline. The ACGIH standards, although not technically consensus standards, were adopted because they had been incorporated into Walsh-Healey standards and were thus considered "existing Federal" standards.* Proprietary standards, i.e., those developed by national organizations using other than consensus methods, were not permitted under Section 6(a) procedures (BNA: 28-32).

The standards adopted by this means have been an endless source of embarrassment to the agency. It is the 6(a) standards, rather than those developed under the notice-and-comment requirements of Section 6(b), that have given rise to charges of "nit-picking," unenforceability, irrelevance, and vagueness. This probelm is not difficult to understand if the purposes of these consensus standards are borne in mind: to protect employers against liability and to serve as recommended guidelines for hazard control. It is not surprising that standards developed toward these ends have not met the quite different goals of the Occupational Safety and Health Act.

---

*However, the list of carcinogens and their zero limits were not adopted, according to the Department of Labor (Ashford: 154).

The Advent of OSHA

Despite widespread agreement that the combined efforts of different levels of government, industry, labor, and private organizations had failed to slow or reverse the rising trend in occupational injuries, there was no consensus about how to remedy the problem. Throughout the 1960's, a variety of job safety and health bills were introduced by the House and Senate, but these died for lack of support. Although Preseident Johnson proposed the first comprehensive national bill to protect job safety and health, it was President Nixon's administration that applied the needed push for federal legislation (Page and O'Brien: 167). During the debates that followed, management interests consistantly favored the Nixon administration's position, while union representatives and supporters backed the Democratic recommendations (BNA: 16-17).

The Administration bill (the Javits-Ayres bill) provided for a separation of standards-setting and enforcement powers, while the Democratic variant (the Daniel's bill) favored placing both standard-setting and enforcement responsibilities in the Department of Labor. The Javits-Ayres bill would have created an independent board empowered but not obligated to develop standards, with members appointed to six-year terms. The unions were adamantly opposed to this version, on the grounds that such a board would be unresponsive to the needs of labor (Page and O'Brien: 169-170). After months of meetings and compromises, and confronted by the strong opposition of organized labor, the Senate and House passed substantively different versions of an occupational safety and health bill. A joint conference committee eventually passed a compromise measure, the Williams-Steiger bill, which gave standards development, inspection, and enforcement powers to the Secretary of Labor, and created an independent review commission (the Occupational Safety and Health Review Commission) (Page and O'Brien: Ch. 8). Among other things, the Bill called for:

(1) Mandatory safety and health standards

(2) Research in the field of occupational safety and health

(3) Training programs for occupational safety and health personnel

(4) An independent review commission

(5) An effective enforcement program

(6) Aid to the states to develop their own plans

(7) Reporting procedures for occupational injuries, fatalities, and illnesses

(8) Encouragement of joint labor-management committees.

In the debates that predated passage of the Act, several areas of controversy became apparent: the role of the states versus that of Federal OSHA; employer versus employee rights; mandatory versus voluntary compliance; protection of employees versus costs of controls; and the meaning of technological and economic feasibility. Throughout OSHA's first twelve years, these same issues have continued to plague the agency and to impede progress in controlling workplace hazards. In this period, agency policy and decisions by the legislative, executive, and judicial branches of government have gradually determined the form of OSHA's response to the challenge of protecting American workers. The history of some of these issues is discussed below.*

---

*The technological-economic feasibility and cost-benefit issues are dealt with in other sections of this report.

The Role of the States

Under the Act, Federal OSHA's occupational safety and health programs preemt those of the states.** States wishing to carry out their own programs must submit a state plan to Federal OSHA for approval. To achieve approval, the plan must incorporate standards and require enforcement "as effective as" Federal OSHA's; for example, the state must have enough properly qualified personnel to enforce its standards. Even after approval, Federal OSHA retains concurrent enforcement authority in the state for three years. Under certain conditions, the Federal Government can regain jurisdiction over occupational safety and health in a state even after approval.

Initially, the Act permitted the states to continue to operate under their own plans, without approval, for a period of two years after enactment; this provision was designed to allow the agency time to structure a program before Federal preemption of the state plans. However, in 1971, OSHA announced a policy of approving developmental plans, i.e., plans that, at the time of submittal to Federal OSHA, did not yet meet the statutory criteria for approval. States submitting developmental plans were required to meet these criteria within 3 years. The unions opposed the idea of developmental plans because they did not believe such plans were authorized by the Act and because they did not believe that state plans generally were effective. OSHA argued that, since Federal enforcement would continue concurrently throughout the developmental stage, employee protection would not be reduced.

As the December 28, 1972, expiration date stipulated for Federal preemption of state plans approached, the Agency proposed "temporary orders," which would have extended the deadline. The unions again opposed, arguing that the temporary orders would allow the states to go on operating under unapproved plans; both the Steelworkers and the AFL-CIO sued OSHA and won. OSHA did not appeal, and the temporary orders were abandoned.

**For the material in this section, I am indebted to Benjamin Mintz, Associate Solicitor of Labor for Occupational Safety and Health, 1970-1981, who has allowed me to use the typescript of his forthcoming book, OSHA--History, Law, and Policy, to be published by the Bureau of Public Affairs in 1984.

The approval of developmental state plans continued, however, and by 1974, 26 states had achieved developmental status. During the tenure of Assistant Secretary Stender, the agency announced that, to avoid duplication in enforcement activities, it would withdraw concurrent Federal enforcement from states whose plans had been granted developmental status (despite the commitment made earlier to continue Federal enforcement until developmental plans had been approved). Both unions and public interest groups objected strenuously to this policy, but OSHA continued to withdraw Federal enforcement under these so-called operational agreements (agreements to lower the degree of Federal enforcement activity) (In January 1983, all states with approved plans--23 in all--had operational agreements, but no state had yet been given final approval.)

Within the state versus Federal context, another area of dispute has been the level of funding and the number of compliance personnel a state must have to achieve the "at least as effective as" benchmark required in Section 18(c)(2) of the Act. OSHA has interpreted this to mean that state levels should be equal to those of Federal OSHA, which have not themselves, for budgetary and other reasons, been optimal. The AFL-CIO has argued that the state must have staffing and funding levels sufficient "to ensure that normative standards are in fact enforced," rather than levels that are only "as effective as" Federal OSHA's.

In a major decision in 1978 (AFL-CIO v. Marshall), the Court agreed with the AFL-CIO, arguing that Congress intended "the approval of current federal levels of personnel and funds as benchmarks for state plans, provided they are part of a coherent program to realize a fully effective enforcement effort at some point in the foreseeable future." However, the Court noted that although current Federal levels, described by OSHA itself as only "a percentage of what is really needed," were adequate as interim benchmarks, they were not adequate as goals for state plans.

> The problems we [the Court] have identified do not necessarily mean that the Secretary erred in giving an initial approval based on present "as effective

> as" criteria. What those problems require is that in addition there be an articulated and coherent program moving from an initial "as effective as" approach toward the personnel and funding levels needed for satisfactorily effective enforcement.

With the concurrence of the AFL-CIO, OSHA announced, in 1980, staffing level benchmarks designed to achieve the "fully effective" rather than "as effective as" criterion. All states with approved state plans would be required to increase the number of safety inspectors from 849 to 1,154 within 5 years, and of health inspectors from 332 to 1,683 in a period of 10 years. The agency also released a benchmark model that could be used to generate or revise staffing levels as necessary. The model considered the hazard rank of various industry sectors and the number of establishments of each rank in each state when calculating the number of general schedule inspectors, the factor that ultimately determines state health and safety staffing requirements.

Confronted with objections to this benchmark plan from the states, OSHA in 1981 announced that it would seek Congressional approval for a rider to an appropriations bill that would prohibit the spending of any funds to achieve state staffing levels greater than current Federal levels. This rider was approved, which in effect nullified the Court order in AFL-CIO v. Marshall. In 1982, OSHA proposed (47 FR 50307, November 5) to recalculate the benchmark formula so that an overall increase in state safety inspectors of 24 percent, rather than the 47 percent increase recommended by OSHA in response to the Court order, would be required. In addition, the 1982 proposal would lower the benchmark for state health staff to an average increase over present levels of 64 percent, compared with the 454 percent increase decided on in 1980.

The benchmarks controversy has been the major obstacle to final approval of state plans, but Federal monitoring of developmental state plans has also contributed. Federal OSHA annually compiles a report evaluating each state plan; Federal state plan monitors on the local level therefore play a major role in deciding when a state plan is sufficiently developed to be given final approval. Since final approval would greatly reduce the number of Federal personnel remaining in the state, it has been argued that monitors have a considerable incentive not to recommend such approval. Recently, OSHA has announced that it has reduced the number of Federal monitors by 50 percent and is revising its monitoring program to rely increasingly on state-supplied data and less on a Federal presence in the states themselves. In 1981, OSHA also withdrew or denied a withdrawal petition against two state plans (Indiana and Virginia, respectively).

The friction over benchmarks, final approval, and Federal monitoring of state plans reflects the underlying tension between the national and the state governments, which were traditionally the overseers of occupational safety and health. Excerpts from policy statements about OSHA over the years demonstrate shifts in the prevailing view of the government's rightful role.

In defense of the Johnson administration's job safety bill, the Secretary of Labor in 1963 acknowledged the failure of the states to protect workers from injury and denied the validity of the states' rights argument in the case of a national occupational safety and health law (Page and O'Brien: 168). In 1970, President Nixon's Secretary of Labor saw a comprehensive Federal law as a way of "placing a foundation under private and state efforts....The promulgation of basic federal safety and health standards will provide a useful starting point for state efforts" (Page and O'Brien: 169).

After OSHA was established, one of its Congressional sponsors, Representative Steiger, explained:

> The plan to allow states to have their own plans is not a "self-destruct" mechanism [for Federal OSHA]....It is based on the belief that resources for this program ought to be spread among the various levels of government with the result that we will have a better safety and health program (Machine and Allied Products Institute 1973).

Congressman Steiger's view of shared Federal-state authority was echoed by OSHA in the President's Report on Occupational Safety and Health for 1973: "Twenty state plans were approved in 1973, bringing to 23 the total number approved since passage of the Act, and moving the United States closer to the Federal/State occupational safety and health partnership intended by Congress" (p. 2). A statement by Assistant Secretary Bingham in 1980 contrasts sharply with this view:

> The Act [instructs] me, as Assistant Secretary, to encourage State plans for the enforcement of standards but clearly that encouragement does not mean acceptance of State performance which results in inferior worker protection. The Act also charges the agency with devising the national program for occupational safety and health as well as monitoring the State's performance and deciding on its acceptability. The Federal agency is given a leadership role which does not lend itself to a traditional partnership of equality as I believe a number of States desire (U.S. Congress, Oversight Hearings on OSHA, Part 4: State Plans, 96th Congress, p. 497, 1980).

A recent policy statement by Assistant Secretary Auchter indicates a return to an earlier stance:

> It is our firm intention to resolve differences that have existed between the States and Federal OSHA and to develop a management and policy framework that in the future will fully integrate the States into the overall OSHA program. It is my belief--and the belief of this administration--that in the last analysis, local problems are best addressed by those closest to them (U.S. Congress, Hearings Before the Intergovernmental Relations Subcommittee of the Senate, 97th Congress, 1981).

It is apparent from these statements that OSHA's state plan program has been significantly affected by shifts in the national political climate in the last 12 years.

Mandatory Versus Voluntary Compliance

Like the state plans program, OSHA's enforcement of compliance with safety and health standards has reflected changes in the national mood; in addition, the enforcement program has engendered the greatest resentment and criticism both among those the agency regulates and those it protects. The Congress intended the primary method of ensuring workplace safety and health to be the enforcement of standards promulgated under the Act. To enforce standards, compliance officers conduct surprise workplace inspections, and they issue citations and propose financial penalties if standards violations are observed. In addition, employers may be cited under the Act's General Duty clause (Section 5(a)(1)) for serious violations of hazards not specifically covered by any standard.

The size of the penalty varies with the severity of the hazard and the employer's prior efforts to remedy it. De minimus and non-serious violations may carry no monetary penalty, while serious violations may be as much as $1,000. Repeated or willful violations may entail a maximum of $10,000. If a willful violation causes the death of an employee, the employer can be prosecuted under criminal law, fined $10,000, and sentenced to 6 months in jail.

At the time of the original citation, an employer is permitted a period of time in which to abate the hazard, and may also contest the citation for a 15-day period after issuance. If an employer contests a citation, the abatement order is stayed until the Review Commission completes its hearings in the matter. The Secretary of Labor is obliged to prove the appropriateness of the citation, the abatement period, and the penalty, and the administrative law judge can vacate, modify, affirm, or increase any aspect of the citation. The judge considers "the size of the business of the employer...,the gravity of the violation, the good faith of the employer, and the history of prior violations" (Section 17(i) of the Act). One of the Review Commission's six commissioners can require the judge's decision to be reviewed by the Commission; the administrative law judge's order, or that of the Commission, is final unless the employer petitions the court of appeals for review. The Secretary of Labor may also seek court review of the Commission's orders. The constitutionality of assessing civil financial penalties without a jury trial was tested and upheld in *Atlas Roofing Company* v. *Occupational Safety and Health Review Commission*, heard by the Supreme Court in 1977.

The enforcement scheme adopted by the Act was intended to reduce the hazards at particular workplaces through citations and penalties issued at those worksites, and to act as a deterrent in workplaces that had not actually been inspected by providing employers with an incentive to abate hazards. The Act's provisions for unannounced inspections and for first-instance citations were intended to operate in this manner. In practice, however, the Supreme Court's 1977 ruling in the *Marshall* v. *Barlow*'s case, which ruled that OSHA inspectors had to have a warrant before a non-consensual inspection could be carried out, has severely undermined enforcement. The practice of issuing small fines (an average of $532 for a serious, willful, or repeat violation in 1979) has provided an economic disincentive to employers by making it less costly to pay the fine than to abate the hazard. Further, the rate of contest of citations has risen from 12 to 21 percent in the 2-year period between 1977 and 1979. While cases are being contested, no hazard abatement is required; since the average case takes 3 years to proceed from citation to final Review Commission order, employee protection may suffer considerably during the process.

These factors explain, although only partially, why studies that use injury rates as indicators of OSHA's effectiveness (or lack of it) report conflicting results, some purporting to show that OSHA has had an impact, others finding the opposite. For example, in 1980 Senator Schweiker maintained that:

> Since OSHA became effective, serious worker injuries--those resulting in time off work--have increased 25 percent, from 3.2 per 100 workers in 1972, to 4.0 per

> 100 workers in 1978....The fatality rate...has decreased 10 percent [although]...in the past two years, comparing 1978 to 1976 data, all of these measurements show increases. The fatality rate [in those two years] is up 13 percent.(U.S. Congress, Oversight Hearings: 2).

At the same hearing, Secretary Marshall countered: "The overall injury rate has dropped from 10.6 injuries per 100 workers in 1973, to 9.2 in 1978, a 13 percent improvement," and the President of the AFL-CIO pointed out that the 10 percent decrease in fatalities alluded to by Mr. Schweiker "means the lives of thousands of workers have been saved" (U.S. Congress Oversight Hearings: 1205). The inability to detect a significant "OSHA impact" on workplace safety has encouraged efforts to increase voluntary compliance by the use of performance rather than specification standards, and by means of on-site consultations.

In 1972, an internal memorandum prohibiting Federal OSHA compliance personnel from conducting sanction-free consultation visits was issued; however, states with approved state plans are permitted to offer consultations. Congress has also attempted to increase the agency's consultative role, particularly for small-business employer's. Despite objections from the unions, the Act was amended in 1974 (the Steiger Amendment) to provide for on-site consultation even in states without approved plans. Federal funding of these consultative efforts was increased from 50 to 90 percent in 1977.

One of the principal problems in the consultation versus enforcement controversy has been defining the obligation of the agency when employers' workplaces were discovered to have serious violations or imminent hazards. In 1977, OSHA decided that violations or hazards discovered during a consultation visit would not be reported to enforcement personnel except in cases of serious violations or imminent hazards which the employer did not abate during the established abatement period. This separation of consultation from enforcement is designed to encourage use of consultation services.

By 1983, all states offered consultation services and all employers, not just small business employers, were covered by the program; in 1980, one out of six OSHA visits involved consultation rather than inspection. These consultations are free to the employer. Another program, instituted in 1982, would exempt employers who take advantage of the consultation program from general schedule inspections for a one-year period; this program is still experimental. Three recent preliminary voluntary protection programs, Star, Try, and Praise, would similarly exempt employers meeting certain safety and health performance criteria from general inspections; these programs will be evaluated for effectiveness as data become available. At present, whether and to what extent voluntary compliance efforts will contribute to achieving the Act's goal remains to be seen.

Employer and Employee Rights

Congress designed the OSH Act with incentives to encourage employers to abate hazards and with rights to encourage employees to participate in all phases of the agency's program. Both voluntary compliance by employers and enlightened participation by employees were seen as ways of augmenting OSHA's limited enforcement staff and of achieving the Act's goals. Employers were assured of due process at every step by such rights as: rulemaking participation, judicial review of standards, contest of citations, court review of Review Commission orders, and participation on advisory committees. In its first decade, however, employees' rights under the law, rather than employers' rights, have received most of the attention.

The most fundamental employee right, beyond that of a safe and healthful workplace, is the right to file a complaint to obtain an inspection of the job site. The complaint must be written, and must describe the conditions alleged to be hazardous. When an inspection takes place, an employee or employee representative is permitted to accompany the inspector. Employees are also protected by a prohibition against employer discrimination against employees who exercise their rights under the Act. Like employers, employees and their representatives may be parties in Review Commission proceedings.

Subsequent court decisions and agency actions have enlarged on or modified employees' rights under the Act. In 1978, the recordkeeping rule was modified (43 FR 31329) to permit employees to inspect and copy the injury and illness log which employers were required by the Act to keep. This employee right has been expanded to permit employees access to medical and exposure records kept by the employer (29 CFR 1910.20). In 1981, the agency proposed a hazard communication standard (the "labeling" standard), in an effort to increase the ability of employees to identify hazardous substances and to protect themselves from the consequences of exposure to such substances. Other issues raised by the labeling rulemaking include the employer's right to keep proprietary information confidential, and employer preference for a single and uniformly applied Federal law in place of several state laws.

The issues involved with employee discrimination are complex, and many have not been resolved by case law. In the DBCP (dibromochloropropane) and lead rulemakings, the questions of "protective" discrimination (protecting workers from reproductive hazards by excluding them from jobs that would expose them to these hazards) was raised. The right to "walkaround" pay (continuance of pay-status while an employee accompanies an inspector on a "walkaround" workplace inspection) has had a varied history. In 1972, the Oil, Chemical, and Atomic Workers filed a complaint under Section 11(c) (the discrimination clause) of the Act because the Mobile Oil Corporation had refused to pay workers accompanying the OSHA inspectors on an inspection walkaround. The Solicitor of Labor responded that since walkaround time was not "working" time, the employees were not paid because they were not "working," within the meaning of the Fair Labor Standards Act. The court ruled:

> This lack of acknowledgement of the pay issue [in the Act] may indicate that Congress did not consider the problem at the time [of the Act]. Whether Congress deliberately or unconsciously omitted provisions for walkaround pay for employees...remains...to the legislative process [to decide].

356

In 1977, in a legal interpretation rather than a proposal, OSHA issued a notice that walkaround time would henceforth be considered working time (42 FR 47334). The Chamber of Commerce challenged this action, and the District Court upheld OSHA on the grounds that failure to pay employees to accompany an inspector was clearly discriminatory. However, on appeal to the U.S. Court of Appeals, the walkaround pay rule was vacated. The appeals court opinion reads: "Walkaround time does not constitute hours worked because it is not an activity controlled by the employer and engaged in primarily for the employer's benefit." The Court also found that the walkaround measure was a legislative rule, rather than an interpretive rule, and should therefore have been proposed under the Act's Section 6(b) rulemaking procedures. In 1981, OSHA issued a final walkaround pay rule developed under 6(b) procedures (46 FR 3852), which has subsequently been revoked (46 FR 18999). The revocation has not been challenged in the courts.

One of the earliest employee rights tested in the court was the right not to be cited for violations of standards implementing the Act. In Atlantic and Gulf Stevedores v. OSHRC (1976), the court concluded:

> With considerable misgivings, we conclude that Congress did not intend to confer on the Secretary or the [Review] Commission the power to sanction employees....It seems clear that this enforcement scheme [the Act] is directed only against employers.

In Atlantic and Gulf Stevedores, the employer asked the court to hold a requirement that employees wear hard hats infeasible, because the longshoremen threatened to strike rather than wear their hard hats.

In addition to court decisions interpreting the meaning of employee rights' provisions, OSHA has issued several policy directives that have enlarged employee rights, such as the 1978 directive (P.D. 200-82) permitting employee participation in the opening, closing, and informal inspection conferences, and stipulating that the employee representative be given copies of any citation issued. (Since no employee representative is available in non-unionized plants, these provisions are necessarily limited to unionized workplaces.)

Employees are also given the right under the Act to refuse to work, in certain limited and hazardous circumstances. In 1973, as part of a regulation interpreting employee rights under Section 11(c) of the Act, OSHA stated:

> ....review of the Act...discloses that...there is no right...which would entitle employees to walk off the job because of potential unsafe conditions at the workplace...[A]n employer would not ordinarily be in violation of section 11(c) by taking action to discipline an employee for refusing to perform normal job activities because of alleged safety or health hazards....However, occasions might arise when an employee is confronted with a choice between not performing assigned tasks or subjecting himself to serious injury or death....If the employee, with no reasonable alternative, refuses in good faith to expose himself to the dangerous condition, he would be protected against subsequent discrimination. (38 FR 2681).

On challenge, the Court of Appeals ruled that the Secretary had exceeded his statutory authority, and vacated the regulation. In a dissenting opinion, Judge Wisdom stated: [Congress believed that] "workers could live with the prescribed processes of this Act...[not] that it required workers to die for them." However, in the *Whirlpool* v. *Marshall* case in 1978, the Supreme Court upheld the right of workers to refuse hazardous work, overturning the lower court's decision.

In another important area for employee rights, the courts have upheld the medical removal protection requirements of the lead standard. These provisions require that employees who have blood lead levels above a specific level be removed from further exposure, and that they retain their pre-removal pay levels (*United Steelworkers* v. *Marshall* (1980)).

Although many of the rights of employees that were envisaged by the Act or have since been proposed by OSHA have withstood repeated attacks in the courts, the agency does not have the resources to handle employee complaints arising from the anti-discrimination clause. In 1980 alone, more than 400 cases found to be meritorious were not sent to court because of lack of personnel to handle the case load (Rothstein: 133).

Summary

Criticism leveled at OSHA in its first decade has come from all quarters and has focused on a wide range of issues. Employees have complained about the "burdens" imposed by the Act, although the average serious violation penalty was $532 in 1979 and the probability of inspection was exceedingly low. For example, for OSHA to conduct one safety inspection per year in high hazard workplaces and one every 10 years in low hazard industries, a safety compliance staff of 7,800 inspectors would be required; in 1980, there were a total of about 4,000 safety and health inspectors in both the Federal and state programs. Complaints about the lack of expertise among OSHA's compliance staff have lessened, since the Agency now requires qualifications and training commensurate with the responsibilities of compliance officers.

The unions have objected to the slow pace of standards development, particularly in health standards, where only 11 final regulations (one of which was a "Policy" rather than a standard) have been promulgated and where the rulemaking often takes three years, after which judicial review may take several more years.

Objections to the "nit-picking" nature of many OSHA citations have been met by the increasing use of inspection targeting to focus attention on high hazard worksites, by revoking many provisions of standards not directly related to employee safety and health, and by directing compliance officers to focus on serious rather than non-serious violations.

Although OSHA critics have been persistent and vocal, the Act itself has not been substantively revised since 1970. However, riders on appropriations bills have limited enforcement in significant ways: in 1980, it was estimated that 120 fatalities and 190,000 injuries would occur in 1980 among workers exempted by these riders from the Act's coverage (Rothstein: 106).

In the final analysis, however, those who would measure "the OSHA effect" on the basis of injury statistics may miss the most significant impact of the Act: the awareness of occupational safety and health hazards among employers and employees alike. Numerical measures of this awareness can be found in many sources: the estimated 250,000 pages in the record of the Cancer Policy rulemaking; the 10,000 workers whose lives have not been lost in the last decade; and the 3,500 complaints filed in 1980 by workers who believed that their employers were discriminating against them for exercising their rights under the Act.* In short, since 1970, occupational safety and health has mattered.

---

*Support for these figures may be found in Rothstein: 79; U.S. Congress, Senate Report, 1980, p. 1205; and Rothstein: 132, respectively.

REFERENCES

Ashford, N.A. Crisis in the Workplace: Occupational Disease and Injury. Cambridge, Mass.: MIT Press, 1976.

Berkowitz, M. Occupational Safety and Health. Ann. Am. Acad. Pol. Soc. Sci. 443:41-53, 1979.

Berman, D.M. Why work kills: a brief history of occupational safety and health in the U.S. Int. J. Health Serv. 7(1):63-87, 1977.

Brody, D. Steelworkers in America. Cambridge, Mass.: Harvard University Press, 1960.

Bureau of National Affairs. The Job Safety and Health Act of 1970. Washington, D.C.: Bureau of National Affairs, 1971.

Carleton, W.G. Government and health before the New Deal. Current History, 1977, 196-224.

Castrovinci, J.L. Prelude to welfare capitalism: the role of business in the enactment of workmen's compensation legislation in Illinois, 1905-1912. In: Compassion and Responsibility. Chicago: University of Chicago Press, 1980.

Corn, Jacqueline K. Historical aspects of industrial hygiene. I: changing attitudes toward occupational health. Am, Ind. Hyg. J. 39(9):695-699, 1978.

Felton, J.S. 200 Years of Occupational Medicine in the U.S. J. Occup. Med. 18(12):809-817, 1976.

Heimann, H., and V.M. Trasko. Evolution of occupational health programs in state and local governments. Public Health Reports 79(11):942-947, 1965.

Kaufman, S., and J. MacLaury. Historical perspectives. In: Protecting People at Work: A Reader in Occupational Safety and Health. Washington, D.C.: U.S. Department of Labor, 1980.

Klem, M.C., and M.F. McKiever. 50-year chronology of occupational health. J. Occupational Medicine. 8(4):225-234, 1966.

Kotarba, J.A. Chronic Pain Center. In: Behav. Scientist 24(6): 786-800, 1981.

Legge, R.T. The history of industrial medicine. Ind. Med. 5 (11) 569-576.

Machinery and Allied Products Institute. Occupational Safety and Health: A Transcript of a MAPI Seminar, Feb. 21-22, 1973. Washington, D.C.

Mintz, B.W., OSHA--History, Law, and Policy. Washington, D.C.: Bureau of National Affairs, in press.

Page, J.A., and M.-W. O'Brien. *Bitter Wages: Ralph Nader's Study Group Report on Disease and Injury on the Job*. New York: Grossman, 1973.

Policy Research Incorporated. Protecting Worker's Health: Federal, State and Local Compliance-Assistance Programs. Contract HHS-100-79-0172, DHHS, Office of the Assistant Secretary for Planning and Evaluation, 1981.

Ravenal, M.P., ed. *A Half Century of Public Health*. New York: American Public Health Association, 1921.

Rothstein, M.A. OSHA After Ten Years. *Vanderbilt Law Review* 34:71, 1981.

Sheehan, J. The past, present and future of OSHA: a labor view. In: *Protecting People at Work: A Reader in Occupational Safety and Health*. Washington, D.C.: U.S. Department of Labor, 1980.

Smith, Robert S. *The Occupational Safety and Health Act: Its Goals and its Achievement*. Washington, D.C.: American Enterprise Institute, 1976.

U.S. Congress, Federal Mine Safety and Health Act of 1977. 95th Congress, Senate Report No. 95-181, 1977.

U.S. Congress, Oversight Hearings on OSHA, Part 4: State Plans. 96th Congress, 2nd Session, 1980.

U.S. Congress, Oversight on the Administration of OSHA, 1980.

Weinstein, J.W. *The Corporate Ideal in the Liberal State: 1900-1918*. Boston: Beacon Press, 1968.

A History of the Consideration of Economic Impacts in the Determination of the Feasibility of Standards Under the OSH Act

Douglas MacLean

Table of Contents

Page

Introduction 1

The Background of the OSH Act and the Controversy Surrounding It. 3

1. Occupational Safety and Health Before the OSH Act 4
2. Regulation and Cost-Benefit Analysis. 7

The Occupational Safety and Health Act of 1970 12

1. The Legislative History 13
2. Cost-Benefit Analysis and the OSH Act 20
3. Cost-Benefit Analysis and Regulatory Reform . 23

OSHA in the Courts 29

1. Asbestos. 31
2. Cost-Benefit and Coke Oven Emissions. 34
3. Showdown in the Supreme Court: The Benzene and Cotton Dust Cases 37

Conclusion 43

Notes. 46

Introduction

The citizens of the United States have built into law a commitment "to assure so far as possible every working man and woman in the nation safe and healthful working conditions."[1] A large part of the history of this national effort to protect the lives of those who toil in our factories and fields comes to focus on a single word -- feasible.

When Congress passed the Occupational Safety and Health Act of 1970 (OSH Act), it directed the Secretary of Labor to set mandatory safety and health standards for the workplace. Those directions, being general and open to interpretation in certain respects, have generated controversy. Most controversial has been the directive to the Secretary for promulgating standards dealing with toxic materials and harmful physical agents. The first sentence of §6(b)(5) of the OSH Act instructs the Secretary simply to:

> set the standard which most adequately assures, to the extent feasible, on the best available evidence, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life.[2]

The rest of the OSH Act, whose numbered and lettered clauses run to thirty pages of fine print, details the procedures for rulemaking and enforcement, provides for research to discover the causes of diseases (especially latent diseases) to which workers are prone, calls for the development of innovative techniques for treating and preventing diseases and harmful psychological effects on workers, and demands better medical records and published lists of toxic substances in the workplace. But nowhere does the Act explain what the Secretary should understand as "feasible." (Nor, for that matter, does it give any gloss on what counts as material impairment of health and functional capacity.) And so the twelve year history of the Occupational Safety and Health Administration (OSHA) has been a constant series of battles -- primarily between OSHA, whatever political party is in power, industry, and organized labor -- over the interpretation of "feasible."

The battles are frequently fought in the courts. Twice in recent years the Supreme Court has considered the central issue, which is the matter in which economic considerations shall be a factor in determining a standard's feasibility. In these two cases, industry representatives brought suit over OSHA's benzene and cotton dust standards respectively. The plaintiffs argued that the agency should have taken economic considerations -- particularly complicance costs -- into account; the agency actions, industry said, would not result in benefits reasonably related to these costs.

We will return later to discuss these two decisions, Industrial Union Department, A.F.L.-C.I.O. v. American Petroleum Institute (the benzene case) and American Textile Manufacturers Institute, Inc. v. Donovan (the cotton dust case), but it is worth remarking on the fact that the Court's decisions in these cases were widely anticipated and subsequently widely discussed, not only in professional journals but also in newspapers and magazines. It would be hard to explain the intense interest these cases provoked if the issue was perceived to be simply a technical one, such as whether the proposed standards were based on good scientific evidence of the health effects of different exposure levels or else whether OSHA was justified in using one technique rather than whatever it did use to reach a judgment on the economic aspects of the feasibility issue.

These OSHA battles are part of a much larger political conflict over regulatory policies and even competing conceptions about the proper role of government. To understand the feasibility issue in its proper context, then, we will have to move from the interpretation of a single word in the OSH Act to a standpoint that takes in not only all of OSHA but also the broader debate over regulatory reform.

The Background of the OSH Act and the Controversy Surrounding It

The broader conflict can be understood, first, in relation to early attempts to regulate safety and health in the workplace and, second, in relation to the development of cost-benefit analysis as an aid to governmental decision making. This section discusses each of these. Then, the next section turns to the OSH Act.

1. Occupational Safety and Health Before the OSH Act

The history of legislating safety and health standards in the workplace stretches back more than a hundred years. By the end of the last century organized labor had successfully pressured many state legislatures to pass regulations requiring minimum safety conditions and setting a maximum number of hours employees could be asked to work. Massachusetts passed a law requiring guards on spinning machines as long ago as 1877.[3]

National legislation at this time, which focused on sanitary conditions in the workplace, reflected a public concern for protecting consumers that was at least as great as the concern for protecting workers. At the turn of the century, muckraking journalists were exposing the dangers that lurked in consumer products -- particularly in patent medicines and drugs -- in articles that appeared in the leading popular magazines of the day, such as Colliers, McClures, and Ladies Home Journal. Together with books like Upton Sinclair's The Jungle, which describes the filth of Chicago's meat packing plants, they created a climate of opinion that led to the Food and Drug Act and the Meat Inspection Act, both passed in 1906.

The state regulations aimed at protecting worker safety and health, however, were from the beginning more controversial.

Early this century, the teachings of Social Darwinism, particularly the writings of Herbert Spencer, were popular in America.[4] These theories emphasized the idea that the interests of society are better served by free competition in the marketplace than by the humanitarian interventions of government. Several Supreme Court decisions expressed this view and hampered the effects to regulate occupational safety and health at the state level. Most notable among these was the 1905 decision in Lochner v. New York which struck down a state law setting a sixty-hour limit on the work week of bakery employees.[5] The Court reasoned that the law infringed fundamentally on the right of workers to sell their labor as they wished to employers. (Nothing was said about the right of workers to petition legislatures to shorten the work week.)

A decade later, a similar controversy was prompted by the attempt to regulate child labor. The national movement to control child labor began in the 1870s when the workforce included 750,000 children under the age of 15.[6] The number and percentage of children working in mines and mills and tending the furnaces in factories increased rapidly, especially in the south where industry moved to escape the regulations that were beginning to pervade the northern states.

Once again, the journalists and writers of the time helped to define the public mood. Some people still remember the verse of Sarah N. Cleghorn, which provides a typical expression of public opinion:

The golf links lie so near the mill
That almost every day
The laboring children can look out
And see the men at play.

Supported by public outrage and disgust at the conditions under which children labored, President Wilson managed to get Congress to pass, in 1916, the Keating-Owen Act, which barred articles produced by child labor from interstate commerce. The Supreme Court struck down the law two years later. The Court made the point that Congress exceeded its power in trying to "standardize the ages at which children may be employed."[7]

In the next twenty years, Congress was unable to pass a child labor law. Its efforts were blocked by a powerful coalition of forces which did not want to see the federal government interfering in the normal practices of business or into the sphere of individual or family freedom to act and to work. The main parties to this coalition were the southern textile industry, the National Association of Manufacturers, and the hierarchy of the Catholic Church.[8] This lobby argued that for the government to interfere with the free market on the basis of a public sentiment would be to deny children their freedom to choose, to threaten parental discipline, and to invade the privacy of the home. It was not until 1938 that Congress succeeded in passing the Fair Labor Standards Act which bars employers, except in special circumstances, from hiring children under 16, or 18 in hazardous occupations. This Act was upheld in the courts.

Thus, we see from the beginning both widespread public support for, but also strong opposition to, attempts to regulate health and safety in the workplace. The opposition was motivated not only by economic interests but by more basic beliefs as well. These were moral and normative beliefs about the proper role of government, justifiable restrictions on individual freedom, and the virtues of consensual solutions to risk and benefit trade-offs reached through the mechanisms of the market. We shall see below how the current debate about feasibility under the OSH Act is strongly reminiscent of these earlier controversies.

2. Regulation and Cost Benefit Analysis

In the New Deal Era, a wave of regulatory activity was aimed primarily at promoting and managing economic activity. The depression shook most people's faith in the idea that an unregulated market best served the public's interests. The problems confronting the nation were clear enough: to manage and conserve natural resources; to stimulate the economy to increase productivity and employment; to initiate public economic and welfare programs, as well as to allocate public goods such as the airwaves and airways; and so on. These problems were generally taken to to be complex and basically technical, so agencies were created where the expertise needed to solve them could be gathered and pooled. The policymakers of the New Deal made it their mission "to create a decision-making structure capable of deploying the relevant expert knowledge."[9] According to James Landis, who wrote extensively about administrative law during the period, "those with experience in legislative matters . . . recognized that it is easier to plot a way through a labyrinth of detail when it is done in the comparative quiet of (an agency) than when it is attempted in the turmoil of a legislative chamber or committee room."[10]

Of course few students of policymaking today would assume that detachment and neutrality reign supreme among the staff of the regulatory agencies, but during the New Deal Era Congress and the public seemed to place great faith in the agencies created by new legislation and in the professionals who staffed these agencies. To be sure, the experts who ran them were not elected officials, but they saw themselves all the more able for this reason to serve the public as a whole rather than any particular constituency. Congress delegated a wide range of discretionary authority to these agencies, so their decisions could be determined by their professional standards and methods.

Cost-benefit analysis came to be employed in this setting as an aid to governmental decisionmaking. The method dates back to Jules Dupuit, a French economist in the nineteenth century,[11] but it was first widely used in the United States only in the 1930's and 40's in the evaluation of public works projects, in particular, investments of public capital in water projects for irrigation, hydroelectric power, and flood control. At the time, economists proposed, quite reasonably, that public investments of this sort ought to return net benefits to society as a whole just as private investments, if they are sound, return a profit to the firm that makes them. Because the government did not have to compete and survive in the market, however, it had neither the information nor the same incentives that guide a firm, and so cost-benefit analysis was to substitute as a guide to public investments. The Flood Control Act of 1939, quite sensibly, called for a comparison of the economic pluses and minuses of major water projects. It permitted the government (in a phrase often quoted in texts on cost-benefit analysis) to finance a project only when "the benefits to whomsoever they may accrue [are] in excess of the estimated costs."

Because the benefits were to be measured wherever they accrued, the analysis of public projects was never as straightforward as estimating the profits or losses in the return on investment. Cost-benefit analysts, then, developed methods of estimating, in dollar terms, the total benefits of a project to society as a whole, i.e., its overall social benefits. They estimated, for example, the difference between the cost of commodities to consumers and the amount those consumers would be willing to pay for those products. The difference, i.e., the surplus to consumers between what they do pay and would pay for goods, indicates the benefit of that commodity to them. Using pricing techniques of this sort, analysts were able to show whether a water project would be economically beneficial to society as a whole even if it did not return a profit to the agency that built and operated it.

Economists developed discount rates in their cost-benefit analyses, moreover, in order to weigh costs and benefits differently according to when they occur. Private investors worry about when they will see the return on their investments, because they borrow money at interest. The government, however, may raise revenues through taxation. Discount rates, therefore, were needed to ensure that investment decisions, whether made by the public or the private sector, take the same kind of economic factors into account.

The use of cost-benefit analysis in water projects is plainly reasonable; it also illustrates th faith policymakers and politicians placed in professional experts and their techniques during the New Deal. Congress succeeded to a large extent in creating agencies to cope with the nation's problems and in delegating a great deal of its lawmaking authority to those agencies. Congress was able to do this, first, because the courts, over the years, took up the slack by exerting control over administrative action, reviewing agency decisions on procedural and even substantive grounds. Second, since most of the nation's problems stemmed from an ailing economy, the goal of the agencies seemed clear enough, namely, to restore the economy to health. Accordingly, the discretion of the administrator, in most agencies, was limited to finding means to accomplish a predetermined end. Again, the assumption was that administrators in the agencies were professional, not political, and the New Deal defenders argued "that it would be unwise for the Congress to lay down detailed prescriptions in advance."[12]

If Congress was passing the buck, then, it was out of faith in expertise and the assumption that the goals of the agencies were agreed upon. When Congress entered its next spate of agency-building with the Great Society programs of the 1960's and 70's, it once again responded to an outpouring of public opinion with laws that created agencies with minimally defined goals and gave enormous discretion to unelected administrators, only this time the reaction was different because the regulatory goals were not basically economic. The legislation passed in response to the civil rights and environmental movements differed in this fundamental respect from the legislation Congress wrote during the Depression. But it was similar in delegating political authority to regulatory agencies. As one commentator wryly states, "Congress is always tempted to turn each new responsibility over to a new independent commission. This is not only following the line of least resistence. It is following a fifty-year-old tradition."[13] When the goals are no longer primarily economic, however, but involve promoting and protecting other values, new problems arise, problems which make the use of cost-benefit analysis controversi[illegible]

The Occupational Safety and Health Act of 1970.

The political consensus of the 1930's formed around the need to rebuild the economy and to provide employment. Beginning around 1965, however, Congress responded primarily to public concern about civil rights, equal opportunity, and environmental quality. It enacted, a remarkable set of statutes, the primary purpose of which was to improve not the economy but the quality of life, e.g., to protect the environment and the public's safety and health. This legislation passed at a time of political consensus and even ideological enthusiasm. Its purpose was not to serve economic or commercial goals; the purpose was morally to make markets more efficient. Rather, these laws were clearly meant to intervene into and control the progress of industrial development in order to serve moral, aesthetic, and humanitarian goals.

The Environmental Protection Act, passed in 1969, was signed into law on New Year's Day, 1970, the same year that the OSH Act, the Clean Air Act, and the Resource Recovery Act were enacted. Further legislation followed shortly -- such as the Endangered Species Act and the Toxic Substances Control Act -- and a number of large and highly autonomous agencies (for instance, OSHA, the Environmental Protection Agency, the Consumer Products Safety Commission) were created to carry out the purpose of this new legislation. These purposes were often clearly stated to make the workplace safer, consumer products less hazardous, the environment cleaner, and so on. The popularity of these laws was shown in a Gallup Poll in 1970, and opinion polls since that time continue to confirm their popularity.[14]

1. The Legislative History

President Johnson began emphasizing the importance of occupational safety and health, not in response to public opinion or interest-group pressure, but, as the story goes, because one of his speech writers, whose brother was involved in research on occupational health, began inserting remarks into the President's speeches.[15] At the same time, following reports of a high incidence of lung cancer among uranium miners, Esther Peterson, an Assistant Secretary of Labor, toured the mines in 1967 and spoke with miners. Deeply touched by this visit, she personally brought the issue to the attention of the Secretary of Labor, Willard Wirtz. Apparently the Labor Department was looking for new programs to propose, and so, thinking that the President's references to occupational safety and health in his speeches indicated some strong personal commitment, Labor included a proposed bill in a package of legislative ideas it sent to the President in late 1967. Without any great lobbying from the Labor Department, President Johnson went along and included a proposal for legislation in his 1968 Manpower Message.

Although this bill was not reported out of committee in either the House or the Senate, it did gain the support of some Democrats in Congress and also the labor unions. Then, in November 1968, a major mine disaster occured in Farmington, West Virginia, which took 78 lives. This accident crystallized a supersaturated atmosphere of public opinion that supported occupational safety and health legislation. The Democrats introduced a bill again in 1969. The newly elected Nixon administration, which opposed this bill, was nevertheless concerned to secure its support among the "silent majority" blue-collar vote, so it felt it had to introduce a bill of its own.

The introduction of a Republican bill virtually assured the passage of some occupational safety and health legislation, and the business organizations that had originally opposed any legislation changed their lobbying strategy to try to get a bill they favored. A bill finally passed, which President Nixon signed into law on December 29, 1970.

The business lobby made it clear that there was a price to pay for a safer and cleaner workplace, but the language in the OSH Act paid little attention to the difficulties of determining trade-offs. These problems would later come to dominate the process of setting standards and defending them in court. The concern most obvious in the OSH Act, however, was to protect the safety and health of workers. The importance of this different emphasis would emerge later. Perhaps one reason economic considerations were not considered more explicitly and in greater detail was that most of those who drafted and passed the OSH Act apparently believed that safety, rather than the far more complicated and costly health standards relating to toxic materials, would be the new agency's dominant concern. Yet, speaking for the AFL-CIO, George Meany, for example, said:

> Every year thousands of workers die slow, often agonizing deaths from the effects of coal dust, asbestos, beryllium, lead, cotton dust, carbon monoxide, cancer-causing chemicals, dyes, radiation, pesticides, and exotic fuels. Others suffer long illnesses. Thousands suffer from employment in artificially created harmful environments.[16]

The legislative history of the OSH Act -- the record of Congressional reports and debates which helps to establish the intent of Congress -- is, in the words of the Supreme Court, "concededly not crystal clear."[17] It does not, in particular, explain what the Congress meant by feasible or how OSHA was to balance economic and technological considerations in setting standards. But even if Congress said too little about balancing costs, and even if it treated them in a way that would provoke the disapproval of professional economists, the legislative history of the OSH Act makes it clear enough that Congress was aware that safety was the goal and that costs were involved.

Neither the original bill introduced in the Senate by Senator Williams nor the one introduced in the House by

Representative Daniels included specific provisions about regulating toxic substances. In both bills, this section was added in committee. The House version was amended to include the following section:

> The Secretary /of Labor/, in promulgating standards under this subsection, shall set the standard which most adequately assures, on the basis of the best available professional evidence, that no employee will suffer any impairment of health or functional capacity, or diminished life expectancy even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life.[18]

The Senate Committee on Labor and Public Works also added such a section, which was nearly identical to the House version except that it instructed the Secretary to set the standard "which most adequately and feasibly assures... that no employee will suffer any impairment of health."[19]

The word "feasible" was proposed by Senator Javitz. In a remark that would prove to be of crucial importance in later court decisions, he explained his proposed modification.

> As a result of this amendment, the Secretary, in setting standards, is expressly required to consider feasibility of proposed standards.

> This is an improvement over the Daniels bill, which might be interpreted to require absolute health and safety in all cases, regardless of feasibility, and the Administration bill, which contains no criteria for standards at all.[20]

When the full Senate Committee reported the bill, it also noted that standards promulgated "shall represent feasible requirements."[21]

The final amendments, which resulted in section §6(b)(5) of the OSH Act as quoted on the first page of this report, were added on the Senate floor. They reflect especially the objections to §6(b)(5) on economic grounds of some Senators. Senator Dominick's views were especially influential. The Senator was worried that "in many cases, the standard which might most 'adequately' and 'feasibly' assure the elimination of the danger would be the prohibition of the occupation itself."[22] In committee, Senator Dominick wanted to strike the entire sentence that Senator Javitz had proposed, but his views did not prevail.

When the bill reached the Senate floor, Senator Dominick rose again to speak out against §6(b)(5). "It's unrealistic," he claimed, "to attempt, as /the Committee's §6(b)(5)/ apparently does, to establish a utopia free from any hazards."[23] The Senator was graphic in the disaster he foresaw. "/L/et us take a fellow," he proposed,

> who is a streetcar conductor or a bus conductor at the present time. How in the world, in the process of the pollution we have in the streets or in the process of the automobile accidents that we have all during a working day of anyone driving a bus or a trolley car, or whatever it may be, can we set standards that will make sure he will not have any risk to his life for the rest of his life? It is totally impossible for this to be put in a bill; and yet it is in the committee bill.[24]

The Senate, then, explicitly considered Senator Javitz's version of the first sentence of §6(b)(5) and refused to delete it. Having failed at this level, Senator Dominick, working with Senators Williams and Javitz, proposed another amendment that he claimed to be "agreeable to all." He proposed limiting the applicability of §6(b)(5) to "toxic materials and harmful physical agents" and deleting the reference to "diminished life expectancy." His third proposed change, the significance of which would surely challenge even the most skilled Talmudic scholars, was to replace the phrase "which most adequately and feasibly assures" with "which most adequately assures, to the extent feasible."[25] The Senate passed these amendments and the bill, and in conference the House accepted the Senate version of the first sentence of §6(b)(5).

The Congress, then, was well aware that the OSH Act required standards that would have significant economic consequences, but it is clear that it intended not to balance costs against health and safety with every standard but to protect health and to regard the costs as socially necessary to bear. Senator Yarborough, a co-sponsor of the Williams bill, said at the time, "We know the costs would be put in consumer goods but that is the price we should pay for the 80 million workers in America." Even more pointedly, he remarked, "We are talking about people's lives, not the indifference of some cost accountants."[26]

Senator Eagleton viewed the costs as "reasonable and necessary costs of doing business."[27] It seems that Senator Eagleton, like other Members of Congress, thought that the financial costs to the nation of health and safety problems in the workplace were greater than the financial costs of eliminating them, an assessment that surely seems dubious today. To the extent that this assessment was generally believed and was a factor in motivating support for the OSH Act, the Congress was relying on a very crude cost-benefit analysis when it passed the law. (This support, by the way, was strong in the end. Although amendments were closely contested along partisan lines, the OSH Act passed the Senate 83-3 and the House 384-5.) But Senator Eagleton also made it clear that his cost-benefit assumptions were not the reason for passing the Act. "Whether we, as individuals, are motivated by simple humanity or by simple economics," he said, "we can no longer permit profits to be dependent upon an unsafe or unhealthy worksite."[28] Nobody in the Congress, it seems, was willing to consider what OSHA was to do should the concerns for simple humanity and simple economics seriously conflict. It was left to OSHA to reason its way to a policy in such contexts, which were to include most of its health standards. This is why the tangle over feasibility emerged.

2. Cost-Benefit Analysis and the OSH Act

The most puzzling question that emerges from a review of the legislative history of the OSH Act is why cost-benefit analysis did not enter the debate at that time. Why, that is, did it not occur in the debates over the economic feasibility of prospective OSHA regulations, to require standards to be justified by cost-benefit analyses or formal risk-benefit analyses?

The likely answer is that it simply did not occur to Congress and its staff that cost-benefit analysis could be applied to balance health risks against economic costs and benefits because the theory and technique of cost-benefit analysis was only simultaneously being developed for such general applications.

We have already seen how cost-benefit analysis was essentially a method for estimating economic costs and benefits that would be more sensitive and comprehensive than a summing up of capital outlays and return on investment. In the late 1950's and early 60's some economists began to see further potential for this technique. Just as the theory of consumer surplus shows "hidden" economic benefits in investment projects, so there were other benefits and costs that did not show up directly in economic calculations. When a river is dammed, for instance, it changes the character of the river and the surrounding environment. Such changes may have economic ramifications, but they also affect the aesthetic and recreational value of the river, and other serious ecological effects as well. Because these changes, which do not show up in economic transactions, matter to people, they should be factored into the methods used to determine government investment decisions. This was the emerging view of many economists. They set out to uncover these over "intangible" costs and benefits and to discover techniques for assigning "shadow prices" to them, that is, prices that do not appear in any markets but which could be included in cost-benefit analysis.

Economists sympathetic to the environmental movement jumped on this idea, as did another group of economists who were concerned to see the United States invest more heavily in the economic development of the third world, investments which the government found difficult to justify on economic grounds. This latter group strongly influenced the development of cost-benefit techniques showing how a change in the discount rate or the addition of a factor or two could change the equation, and they managed to produce ingenious arguments to justify various policy changes.[29]

Thus began a process in which cost-benefit analysis came to be used not only to estimate economic returns on economic investments, but to evaluate government activities of almost any kind. The use of cost-benefit analysis came to mean, for many people, that all costs and benefits of whatever kind would be "priced" and included in the evaluation of an agency decision.

In 1969, at the same time as the OSH Act was working its way through Congress, Chauncey Starr published an article in Science, called "Social Benefits versus Technological Risk," in which he suggested a way to extend cost-benefit techniques to price incremental changes in risk to life and health.[30] The marginal values were taken from the preferences people reveal in their demand for safety products or in their willingness to engage in risky activities where the compensating benefits could be measured. Starr suggested that these values could be used to assess proposals to reduce risk through regulations that impose significant costs to industry.

Starr was concerned with technologies, especially nuclear power, but it was easy to see how his technique might apply to proposals to reduce risk in the workplace. One might set safety standards in the workplace to mimic the trade-offs between risk and money consumers make in society as a whole, for example, in equipping their cars with safety devices. One might even try to determine the trade-offs that workers make themselves, when they are free to choose, and then enforce the resulting safety levels as a mandatory minimum. OSHA has not adopted this risk-cost-benefit approach.

3. Cost-Benefit Analysis and Regulatory Reform

Whether by coincidence or for some other reason, health and safety standards were promulgated at the same time inflation became a major economic problem in the United States. As a result, people paid more attention to the economic feasibility of different exposure standards. This attention galvanized in a series of Executive Orders emphasizing the economic effects of regulation.

President Ford issued the first of these, Executive Order 11821, on November 27, 1974. This Order required all major rules or regulations issued by any executive branch agency to be accompanied by "a statement which certifies that the inflationary impact of the proposals has been evaluated." It also empowered the Director of the Office of Management and Budget to develop criteria for identifying major rules and for considering how the inflationary impacts would be evaluated. Just before leaving office, President Ford extended this order, without significant change, through Executive Order 11949 (issued December 31, 1976).

On March 23, 1978, President Carter issued his own Executive Order on this topic, E.O. 12044, which bore the title "Improving Government Regulations." E.O. 12044 attempted to implement in a comprehensive way the economic impact statements required under the previous administration. E.O. 12044 concentrated the control over this process more explicitly in the Office of Management and Budget, and it defined a "major rule" as one whose annual economic effects exceed $100 million. It specified, moreover, that

> Each regulatory analysis shall contain a succinct statement of the problem; a description of the major alternative ways of dealing with the problem that were considered by the agency; an analysis of the economic consequences of each of these alternatives and a detailed explanation of the reasons for choosing one alternative over the others.[31]

The careful wording of E.O. 12044 does not set economic criteria for determining standards. OSHA still was free to interpret feasibility in terms of technological capability. Whatever political signals might have been sent to OSHA, E.O. 12044 demanded only that when the agency set a standard for toxic materials, it estimate and report the likely economic consequences.

But pressure was building, both inside and outside the government, to use cost-benefit analysis to justify OSHA standards. OSHA, as we shall see, resisted this pressure. The struggle peaked at the time that President Reagon took office. The Supreme Court had recently considered OSHA's benzene standard in a case where the failure to use cost-benefit analysis was raised as an issue, but it decided the case on other grounds. The Court soon agreed, however, to consider the cotton dust case which more explicitly raised the cost-benefit issue. Before that case was heard, President Reagan issued Executive Order 12291.

E.O. 12291 appeared in the Federal Register on February 19, 1981. It was one of President Reagan's first acts in Office and would later be described by the White House as the central component in the campaign for "regulatory relief," which was seen as "a key element of the President's economic recovery plan."[32] On a casual reading, E.O. 12291 looks like a further development in the series of executive orders aiming to assure that the economic impacts of regulations are considered before a standard is promulgated. It further strengthens the role of the Office of Management and Budget in this process, establishes a Task Force on Regulatory Relief to review agency and OMB decisions, and it makes the procedure for preparing what is now called a Regulatory Impact Analysis more explicit.

But a careful reading of E.O. 12291 shows a fundamental shift between this and the earlier executive orders in the direction of cost-benefit analysis. The earlier orders had required the agencies to evaluate the economic impacts and to take them into account in their decisions, but they made no attempt to set criteria or goals for regulation. E.O. 12291 uses the language familiar to cost-benefit analysis and says: "Regulatory action shall not be taken unless the potential benefits to society for the regulation outweigh the potential costs;" and, further, that "regulatory objectives shall be chosen to maximize the net benefits to society;" and that, where an objective is given, "the alternative involving the least net cost to society shall be chosen."[33] E.O. 12291 further required that benefits and costs be quantified in monetary terms to the extent possible, and that the benefits and costs that cannot be thus quantified should also be identified.

The Reagan administration's fundamental departure from its predecessors in its approach to regulation was explained in the February 1982 Economic Report of the President, a remarkably lucid and forthright document.[34] In its chapter on regulatory reform, the President's economists explain the rationale for regulation.

> Why do governments become involved in regulating private economic activity? The question is not, of course, a simple one to answer, and numerous justifications for public intervention in the private sector have been offered. The basic reason advanced by economists is the occurrence of "market failure" -- that is, the failure of competitive market forces to function efficiently

> in the allocation of goods and services. When there is no market failure, most economists would conclude that decentralized market decisions are superior to centralized government regulation.[35]

While many of the regulations promulgated during the New Deal might be construed as attempts to correct market failures -- particularly to restrain the effects of monopoly -- the environmental, health, and safety legislation of the 1960s and 70s, as we have seen, called for regulation for other reasons. A strong political and moral consensus had formed around the view that the death rate on the job was too high, the environment had become too polluted, and consumer products, like cars, were too unsafe. The picture of carnage, whether in the workplace or on the road, is not a pretty sight, and it is not made any prettier by the thought that drivers were free to buy seat belts and workers were free to choose other jobs. Congress responded for obvious moral and political reasons to what was plainly an excessive number of deaths and injuries -- that is, excessive from the point of view of people who think in moral and humanitarian terms. Congress did not wait to see, then, whether standards that could eliminate a great number of deaths at a manageable cost could be justified on cost-benefit grounds.

Executive Order 12291 and the subsequent Economic Report embody a theory of legitimate government activity that comes directly into conflict with the conception or theory implicit in the OSH Act and, indeed, in most legislation. The Economic Report, in one of its few remarks about workplace safety, correctly states:

> Observed differences in safety conditions among workplaces, for example, are not sufficient evidence of a market imperfection, because employer and employee knowledge of these conditions may lead to compensating differences in wages and employment conditions.[36]

This is quite true and to the point. At the end of the last century, little children "hurrying" coal in the mines were paid more than children who worked in sweat shops. Thus the many thousands of deaths among these children were not market failures -- because the children received a few cents more each day to take the extra risk. It was all done in an open and informed market. Likewise, when bakers worked fifteen hours a day at their ovens and died from that, no one could construe their deaths as a market failure, because they knowingly ran that risk for a few extra cents. And so on. No matter how much carnage there is -- no matter how morally appalling and how disgraceful the body count may be -- these deaths may represent the outcome of the functioning of an efficient market. To regulate markets to produce fewer deaths -- to keep children in school, for example -- would be to prevent markets from operating efficiently, that is, through voluntary and informed transactions.

The idea that the government should not interfere in voluntary markets -- and thus with the right of individuals to negotiate their own working conditions -- is implicit in the President's Executive Order, in the Economic Report, and in the present attack on OSHA regulators. This attack marks the resurgence of a view once associated with the Lochner decision and even with Social Darwinism: the view that the competition of individuals in the marketplace suitably expresses a view of ourselves as a free, humane, and civilized society. The call for cost-benefit analysis sounds a familiar note. It would substitute the rule of markets for the rule of law. It would replace the moral and political consensus of our nation with a theory -- a particular conception -- of regulatory policy, and thus do an "end run" around the purposes of legislation.

OSHA in the Courts

OSHA's first task, when it was created in 1971, was, as required by the statute, "to promulgate as an occupational safety or health standard any national consensus standard, and any established federal standards." These were standards generally in use by industry to which litigants appealed, for example, in settling negligence claims. Within one month of taking office, OSHA's first Administrator, George Guenther, adopted thousands of these standards, including about 400 which set limits on worker exposure to toxic chemicals.

Guenther did not have the staff to reevaluate these standards, nor was he required to reevaluate them. They had the force of law virtually with the passage of the OSH Act.

Although the safety problem was quite a serious one -- a 1976 estimate claimed an annual rate of 2.2 million disabling, safety-related occupational injuries each year, including 14,000 fatalities -- many of the regulations first adopted and then enforced were quite petty.[37] These included the rules requiring split toilet seats and proscribing ice cut from frozen ponds, examples of the kind of silly rules that were to bring infamy to OSHA in its early days.

Health regulations, however, were soon to become the dominant concern at OSHA. Here the problem was quite different. The elaborate rulemaking procedures -- which include opportunities for hearings and judicial review -- the difficulty of establishing the scientific bases for health standards, and the costs to industry, led to bitter political struggles and almost invariably to subsequent litigation. Each standard has taken years to wind its way through this maze, and as a consequence OSHA has managed to promulgate only 13 health standards since 1971 (including the 14 carcinogens regulated in 1974 as one standard). Through this process OSHA has been forced to define "feasibility" more precisely than Congress had done. We will mention some of the high points of recent OSHA history as they relate to the way economic considerations were taken into account.

1. Asbestos

In 1972, OSHA issued its first toxic substance standard for asbestos. The exposure dose is measured in terms of the number of fibers above a given length per cubic centimeter in the workplace environment. The consensus standard was 12 fibers, but evidence was available that this level posed a serious risk to workers who could be disabled or killed as a result of inhaling asbestos dust.

OSHA agreed with the National Institute of Occupational Safety and Health (NIOSH), a government research agency, that no level of exposure to asbestos dust was known to be safe. NIOSH had recommended that a 2-fiber limit should be made effective in two years. In hearings on the standard, however, labor unions argued that the standard should be set at 0 fibers, since only a 0-exposure level could assure safety. The unions argued that this was a technologically feasible goal. They claimed further that technological feasibility was all OSHA was permitted to consider. Although some industry representatives argued that there was not sufficient evidence to change the current standard, most of them sought a 5-fiber limit, claiming that they could not meet the 2-fiber standard NIOSH suggested.

OSHA deliberated between a 2- and 5-fiber limit and decided finally on a 5-fiber emergency standard effective immediately (1972), with a 2-fiber permanent standard effective in 1976. OSHA noted in its proposal that "/m/ost medical opinion is divided between a two-fiber and a five-fiber standard."[38] Its four year period for compliance was "deemed necessary to allow employers to make the needed changes for coming into compliance."[39] It is estimated that no additional harm would come to workers as a result of the transition period. In this determination of feasibility, OSHA clearly attempted to balance its concern for workers' health with considerations for the burden on industry of compliance.

The Industrial Union Department of the AFL-CIO took the ruling to court, in a case that was decided by the District of Columbia Circuit Court of Appeals in 1974.[40] The issue brought by the Industrial Union Department raised the question whether OSHA was permitted under §6(b)(5) of the OSH Act to consider economic factors in setting permanent standards for toxic substances.

The Court, citing Senator Javitz's remarks ruled that OSHA could consider economic effects in determining a standard's feasibility.[41] It ruled that feasibility would not permit standards that would put a whole sector of industry out of business, but let remain the possibility that particular firms might be forced to close because they could not meet a standard.[42] The Court also ruled that OSHA can go beyond established scientific data in setting limits for exposure to toxic substances, thus acknowledging the difficulty of establishing proof in this area.[43] The Court, that is, would not review the scientific evidence used to set standards, except to scrutinize OSHA decisions to make sure the agency had not been arbitrary or irrational. Finally, the Court established a dual standard for reviewing OSHA decisions. OSHA, when challenged, must 1) explain why it chose to follow the course it did, rather than some alternative, and 2) identify which of its conclusions rest on facts and which on policy judgments.[44] The Court went on to criticize OSHA for the four-year extension to meet the two-fiber limit, claiming that it should have shown whether this was "necessary."[45]

The decision in the asbestos case, then, established that OSHA was permitted to take economic effects into consideration but that it must establish the economic necessity for delaying the effective date of its standard. The Court also recognized that OSHA decisionmaking demands policy judgments which may not be based on purely factual analysis.

Subsequent decisions involving other standards here elaborated and confirmed the interpretation of "feasibility" given in the asbestos case. In AFL-CIO v Brennan (1975), a case involving OSHA's standard for mechanical power presses, the 3d Circuit Court of Appeals followed the asbestos ruling about economic aspects of feasibility.[46] It declared that OSHA cannot "disregard the possibility of massive economic dislocation caused by an unreasonable standard. An economically impossible standard would in all likelihood prove unenforceable."[47] This case is also notable for interpreting feasibility in the OSH Act to allow "technology-forcing" standards. This meant that OSHA "would not be justified in dismissing an alternative to a proposed health and safety standard as infeasible when the necessary technology looms on today's horizon."[48]

2. Cost-Benefit and Coke Oven Emissions

In 1976, OSHA was considering a petition from the American Iron and Steel Institute to lower the acceptable standards for coke oven emissions. Coke ovens, which are used widely in steel mills, normally emit coal tar pitch volatiles containing several carcinogens to which thousands of workers are exposed. By the time OSHA was ready to promulgate a new standard, cost-benefit analysis had become firmly entrenched as a tool in regulatory reform. President Ford's Council on Wage and Price Stability was urging OSHA to adopt cost-benefit as its method for determining the economic feasibility of its standards. OSHA dug in its heels, and when it issued its new coke oven standard it stated its reasons for not adopting cost-benefit.[49]

First, partly because of the technology-forcing effect of its rules, the compliance costs to industry are too difficult to determine with the precision needed for reliable cost-benefit analysis. OSHA mentioned that concerned parties presented a wide range of cost estimates at public hearings. OSHA took the position that "it would be inappropriate to accept any one of these estimates as its own or to make a definitive estimate of the actual costs necessary to comply with the proposed standard."[50] OSHA deemed it appropriate only to narrow the range of estimates to be sure it was not causing massive dislocation of industry.

The more important point, however, concerned the need to quantify and monetize the benefits of life and health in order to include them in a cost-benefit analysis. OSHA was rather forceful on this point. It concluded:

> There are insuperable obstacles to any attempt to estimate accurately and to reduce to dollar terms the value of any health regulation.... [T]here are so many difficulties involved in attempting to assign a dollar value to the benefits of the standard that such figures would not provide a meaningful indication of the true value of the standard.[51]

One of the obstacles OSHA cited was technical. With slightly different assumptions (and no conclusive reason for choosing between them) you get very different estimates of health and mortality effects of the proposed standard. A further problem arises because the most important benefits from the standard are not immediate but occur perhaps 20 years down the road, only then will you know whether today's workers are healthy or dying from cancer. "In our view," OSHA maintained,

> the final rule provides immediate benefits relating to mortality by protecting employees today so that their mortality will be significantly reduced in the future. In these circumstances, we believe that it would be inappropriate to attempt to speculate on the reduced yearly mortality which will result from the final rule.[52]

More interestingly, however, and perhaps more to the point at issue, OSHA alluded to the philosophical and moral problems involved in trying to quantify and monetize the value of human lives.[53] It reviewed some of the methods specifically proposed for doing this. The "human capital" approach values the lives of workers according to estimated lost earnings due to early deaths. OSHA pointed out that this approach is inequitable because members of low-income groups (e.g., retired persons, blacks, women) are valued less highly and sometimes are held to be worthless. The "net output" approach calculates the discounted present value to others of the losses accruing over time as a result of someone's death, a method which "implies that the death of any person whose earning power or productivity is negative... represents a net benefit to society. The method has no regard for the feelings of the potential victim or his family...."[54]

Two other methods considered involved comparison of OSHA costs to the benefits and costs of other social programs to control risk (a kind of generalized cost-effectiveness approach), and one that tried to derive a value for reduced risk from differential wage rates in hazardous occupations. OSHA cited several problems with these approaches. It pointed out that a democratic society might favor differentials among programs, that knowledge of hazards and the latency of effects might hinder workers' decisions about balancing wages and risks, and even that different ways of dying might be important to people. "/T/here appears no way to value a difference between the slow and painful process of dying from cancer as compared to other dying processes with different levels of pain and suffering."[55]

The conclusion in the coke oven notice is blunt. "OSHA believes that these methodologies do not adequately quantify the value of life. Accordingly, we decline to do so."[56] OSHA found that compliance with the proposed standard "is well within the financial capability of the coking industry."[57] By implication, it was stating that this is finding enough. The standard is feasible.

3. Showdown in the Supreme Court: The Benzene and Cotton Dust Cases

OSHA's initial health standards survived judicial review fairly well. In the process, the agency's working criteria for setting standards began to evolve and to become more clear and specific than the vague language in the OSH Act. OSHA standards could be technology forcing, if the agency could show that the technologies needed to meet its standards were on the horizon; standards could be based on partial and sometimes uncertain scientific evidence, because, given the nature of epidemiological evidence and the time lag involved between exposure and the onset of disease, OSHA would not be able to prove its dose-response estimates until after the damage to workers had been done; yet OSHA could not impose on industry a burden so heavy that an entire industrial sector would be driven out of business. This is how technological, scientific, and economic factors were all to count to determine a standard's feasibility under § 6(b)(5) of the OSH Act. What was not required, it seemed, was quantification of benefits and costs and vindication by cost-benefit analysis. OSHA had agreed that this task was too speculative and too difficult, and the courts seemed to accept the agency's judgment.

Things changed in 1978, when OSHA proposed revising the standard for permissable exposure to benzene from 10 parts per million to 1 ppm. Approximately 11 billion pounds of benzene are produced in the United States annually, most of it used as an additive in gasoline and in petrochemical products, and over a million workers, most of them gas station employees, inhale fumes in their air. At high levels of exposure, benzene inhalation is generally fatal, and for more than half a century health experts have theorized that lower levels of exposure increase the risk of leukemia. OSHA claimed that no safe level of exposure could be established, and in the absence of some threshold level it was required to set the standard that was the lowest one feasible, in terms of technological and economic possibility as it had come to understand them. OSHA accepted NIOSH's recommendation of 1 ppm, arguing that engineering controls could meet it and that industry was able to pay the cost.

The American Petroleum Institute appealed the decision in the 5th Circuit Court of Appeals, and the standard was struck down. The 5th Circuit ruling did not attempt to redefine feasibility under §6(b)(5), however, but appealed to the definition of a health standard in section §3(8) of the OSH Act as requiring "practices, means, methods, operations, or processes, reasonably necessary or appropriate to provide safe or healthful employment or places of employment." (emphasis added) The Court ruled that "reasonably necessary" required OSHA to make quantitative risk estimates showing the benefits of the proposed standard and to show quantitatively that the benefits bore a "reasonable relationship" to the costs.[58] The question of cost-benefit analysis was thus raised anew.

The Industrial Union Department of the A.F.L.-C.I.O. appealed the decision to the Supreme Court, which agreed to hear the case and apparently to consider the crucial question whether

OSHA must justify its standards with an analysis -- presumably quantitative -- that showed that benefits outweighed costs. The court's ruling, which was announced on July 2, 1980, was completely indecisive on this issue.[59] The Court upheld the 5th Circuit decision but explicitly refused to endorse its reasoning. The justices voted 5-4 to strike down the OSHA standard, but there was no majority opinion. Only Justice Powell, in a separate concurring opinion, suggested that he would require OSHA to "determine that the economic effects of its standard bear a reasonable relationship to the expected benefits."[60] The principal opinion of Justices Stevens, Burger, Stewart, and Powell refused to rule on the cost-benefit question at all, but upheld the 5th Circuit decision on the entirely separate grounds that OSHA had failed to show that benzene "more likely than not" poses a significant risk of cancer at the original 10 ppm level.[61]

Justice Rhenquist, meanwhile, cast the fifth vote against the standard, but on totally different grounds. He found with the dissenters that "reasonably necessary" in §3(8) had no meaning,[62] but unlike them, he argued that "feasibility" in §6(b)(5) is likewise so imprecise as to make meaningful judicial review impossible.[63] Justice Rhenquist would have held parts of the OSH Act unconstitutional for failing to give the administrative agency more precise direction. He was thus trying to revive the nondelegation doctrine which had been last used in the 1930's to strike down certain New Deal legislation that delegated too much legislative power to those outside government as well as to the executive branch.[64] Rhenquist appealed to the philosopher John Locke, who wrote that "The power of the legislative...being only to make laws, and not to make legislators,...can have no power to transfer their authority of making laws and place it in other hands."[65] Justice Rhenquist, then, was not about to determine that the OSH Act required cost-benefit analysis.

The dissenting opinion, written by Justice Marshall and joined by Justices Brennan, White, and Blackmun, determined that the "reasonably necessary or appropriate" clause of §3(8) meant only that standards must bear a reasonable relation to the purposes of the OSH Act. They ruled that the key statutory provision is stated in §6(b)(5), and they agreed with OSHA that feasibility analysis does not call for a weighing of costs and benefits. Having failed to resolve the cost-benefit issue in the benzene case, the Supreme Court soon accepted another relevant case for the following term.

Workers in cotton mills who are exposed to cotton dust suffer a high risk of contracting byssinosis , a disabling lung disease which, in the early 1960's, was recognized to be a unique occupational hazard associated with cotton mills. An estimated 25% of workers exposed to cotton dust suffer from mild forms of the disease, whose symptoms include shortness of breath, coughing, and wheezing, and 1 in 12 workers suffers from more extreme forms of byssinosis , which is an irreversible, disabling, chronic disease similar in its effects to chronic bronchitis or emphysema and which contributes to heart failure.

Working conditions in cotton mills were one of the important issues leading to the passage of the OSH Act, and so perhaps the only surprise about the new standard OSHA promulgated for cotton dust exposure was that it was not announced until 1978. The standard was challenged by the American Textile Manufacturers Institute for several reasons, among them the familiar complaint that OSHA had not shown a reasonable relationship of benefits to costs which, it was argued, is required under section §3(8) of the OSH Act. The OSHA standard was upheld in the Circuit Court of Appeals, and the decision was appealed. This was the case the Supreme Court agreed to hear. It affirmed the Appeals Court decision by a 5-3 decision announced June 17, 1981.[66]

The majority opinion finally decided the cost-benefit issue. Justice Brennan, writing for the majority, the critical phrase "to the extent feasible" in §6(b)(5). He ruled that

> Congress itself defined the basic relationship between costs and benefits, by placing the "benefit" of worker health above all other considerations save those making attainment of this "benefit" unachievable. Any standard based on a balancing of costs and benefits by the Secretary

> that strikes a different balance than that struck by Congress would be inconsistent with the command set forth in §6(b)(5). Thus cost-benefit analysis by OSHA is not required by the statute because feasibility analysis is.[67]

The majority opinion, in this passage, strikes an ironic note. Congress, in requiring that the health of workers be protected insofar as feasible from exposure to toxic chemicals, spoke for the conscience of the nation. It expressed a view to which most Americans would agree, namely, that too many workers have died in the nation's factories and mines and that the carnage has to stop. This statement of conscience -- this view of what we stand for -- cannot be construed as a cost-benefit analysis. Nevertheless, the Court brought the message home to those who do not think in ethical but only in economic terms. In requiring the workplace to be less hazardous as distinct from more efficient Congress itself had balanced the benefits and the costs.

Conclusion

The Opinion in Cotton Dust should settle the question whether OSHA may use cost-benefit analysis in setting standards for worker exposure to toxic substances. W. Kip Viscusi, an authority on OSHA and a proponent of cost-benefit analysis, recognizes this fact. "The Supreme Court," he writes, "has explicitly prohibited the use of a cost-benefit test for OSHA standards pertaining to toxic substances and hazardous physical agents."[68] The OSH Act places worker health in the same category as the prohibition of child labor and the minimum wage. These regulations express our image of ourselves as a civilized nation; they are part of a history of which we need not be ashamed. Those who would use cost-benefit analysis to make moral and aesthetic judgments -- who would substitute the rule of markets for the rule of law -- would reverse that history. They would deny workers their political victory and all citizens their political rights to representation not just in markets but also through the political process.

Executive Order 12291 directs the Office of Management and Budget to review major regulatory actions on essentially cost-benefit grounds insofar as this kind of review is not prohibited by law. The Supreme Court has made this prohibition clear in respect to OSHA standards relating to toxic substances. Since the OMB review process goes on behind closed doors, however, and since the reasons for which it declines to approve a regulation need not be on the record, it may nevertheless stop regulations which do not pass a cost-benefit test. Viscusi, among many others, has too much respect for our democratic traditions to approve this kind of end-run around legislation. He writes:

> To be sure, OMB can nevertheless address benefit-cost issues in its regulatory review process; but the courts could entertain suits that

> would enjoin the administration from blocking regulations on benefit-cost grounds, should the reason for the OMB decision become public.[69]

Cost-benefit analysis has a chameleon-like quality in that it conforms to the purposes of those who use it.[70] During the New Deal and again in the 1960s and early 1970s, liberal policymakers, wishing to justify governmental interventions into the functioning of markets, described those interventions as necessary to "correct" a market failure. Since market failures are endemic in a large, complex, technological economy, a partisan is nearly always able to find one to support his policy. Today, policymakers wishing to curtail rather than to extend government regulation appeal to the same device, if only to lay another level of bureaucratic review over the many existing ones. Cost-benefit analysis has become -- and is now inevitably -- a political weapon and serves political not economic purposes. As a congressional staff scientist has said, the call for cost-benefit analysis or risk-benefit analysis "is the invention of those who do not wish to regulate, or to be regulated. . . . Its primary use in government decision-making is to avoid taking action which is necessary or desirable in order truly to protect the health of the public or the integrity of the environment."[71]

Notes

1. 29 U.S.C. §651(b).
2. 29 U.S.C. §655(b)(5).
3. For discussion, see Nicholas Ashford, Crisis in the Workplace (Cambridge, Mass.: MIT Press, 1976), pages 47-50.
4. For a history of social Darwinism in the United States, see Richard Hofstadter, Social Darwinism in American Thought (New York: Brazilles, revised edition 1959).
5. 198 U.S. 45 (1905).
6. See Clarke Chambers, Seedtime of Reform (Minneapolis: University of Minnesota Press, 1963).
7. Hammer v. Dagenhart, 247 U.S. 251 at 271 (1918).
8. See Chambers, Seedtime of Reform.
9. Bruce Ackerman and William Hassler, Clean Air/Dirty Coal (New Haven: Yale University Press, 1981), page 4.
10. James L. Landis, The Administrative Process (New Haven: Yale University Press, 1938) pages 69-70.
11. Dupuit's classic article, "On the Measurement of Utility of Public Works," was published in 1844.
12. Richard Stewart, "The Reformation of American Administrative Law," Harvard Law Review 88 (1975): 1678.
13. Report of the Presidents' Commission on Administrative Management (1937), cited and discussed in J.O. Freedman Crisis and Legitimacy: The Administrative Process and American Government (Cambridge: Cambridge University Press, 1978), chapter 2.

14. See U.S. Council on Environmental Quality, Public Opinion on National Environmental Issues (Washington, D.C.: U.S. Government Printing Office, 1980).

15. This account is given in Joseph Page and Mary Wyn-O'Brien Bitter Wages (New York: Grossman, 1973), chapters 7-8. Also see Steven Kelman, "Occupational Safety and Health Administration," in The Politics of Regulation, edited by James Q. Wilson (New York: Basic Books, 1980), pages 238-243.

16. Occupational Safety and Health Act of 1968 (Hearings before the Select Subcommittee on Labor of the House Committee on Education and Labor, 96th Cong., 2d sess., February 1 - March 14, 1968), page 704. Quoted in Kelman, "Occupational Safety and Health Administration," page 243.

17. American Textile Manufacturers Institute, Inc., v. Donovan, 101 S. ct. 2478 (1981) at .

18. Subcommittee on Labor of the Senate Committee on Labor and Public Welfare, Legislative History of the Occupational Safety and Health Act of 1970 (Washington, D.C.: U.S. Government Printing Office, 1971), page 834.

19. Ibid., 242.

20. Ibid., 197.

21. Ibid., 147.

22. Ibid., 367.

23. Ibid., 480.

24. Ibid., 481.

25. Ibid., 502.

26. Ibid., 444.

27. Ibid., 1150-1151.

28. Ibid.

29. See, for example, Amartya Sen, "Isolation, Assurance and the Social Rate of Discount," Quarterly Journal of Economics 79 (1965): 112-24.

30. Chauncey Starr, "Social Benefits versus Technological Risk," Science 165 (September 19, 1969): 1232-38.

31. E.O. 12044, Sec. 3(b)(1), 43 Fed. Reg. 12663, March 24, 1978.

32. See Economic Report of the President: Transmitted to the Congress February 1982 (Washington, D.C.: U.S. Government Printing Office, 1982), page 141.

33. E.O. 12291, Sec. 2(b), (c), and (d), 46 Fed. Reg. 13193, February 19, 1981.

34. Supra., note 32.

35. Ibid., p. 135.

36. Ibid., p. 138.

37. These figures are from a Bureau of Labor Statistics study cited in Ashford, Crisis in the Workplace, page 46. For a general discussion of the adoption of consensus standards under section 6(a) of the OSH Act, see Thomas Barton "Deciding What to Regulate: Priority-Setting at OSHA, Virginia Journal of Natural Resources Law 2 (1982): 87-121, pages 95-96.

38. "Standard for Exposure to Asbestos Dust," 37 Fed. Reg. 11, 318 (1972).

39. *Ibid.*, pages 11, 318-19.

40. *Industrial Union Department, AFL-CIO v. Hodgson* 499 F.2d 467 (D.C. Cir. 1974).

41. The court advanced the following analysis of feasibility:

> /P/ractical considerations can temper protective requirements. Congress does not appear to have intended to protect employees by putting their employers out of business -- either by requiring protective devices unavailable under existing technology or by making financial viability generally impossible. (*Ibid.*, 477-73.)

42. *Ibid.*, 478.

43. *Ibid.*, 474.

44. *Ibid.*, 475-76.

45. *Ibid.*, 479.

46. *AFL-CIO v. Brennan* 530 F 2d 109 (3d Cir. 1975).

47. *Ibid.*, 123.

48. *Ibid.*, 121.

49. "Exposure to Coke Oven Emissions, 41 Fed. Reg. 46742-90 (October 22, 1976).

50. *Ibid.*, 46749, col. 2.

51. *Ibid.*, 46750, cols. 1-2.

52. *Ibid.*, 46751, col. 1.

53. *Ibid.*, 46751.

54. *Ibid.*, 46751, cols. 1-2.

55. *Ibid.*, 46751, col. 2.

56. *Ibid.*

57. *Ibid.*, 46751, col. 3.

58. 581 F 2d 493 (5th Cir. 1978), at 502.

59. *Industrial Union Dep't., AFL-CIO v. American Petroleum Institute, Inc.*, 100 S.ct. 2844 (1980).

60. *Ibid.*, 2877.

61. *Ibid.*, 2860.

62. *Ibid.*, 2883.

63. *Ibid.*, 2886.

64. *Ibid.*, 2886-87.

65. *Ibid.*, 2879.

66. *American Textile Manufacturers Institute v. Donovan* 452 U.S. (1981).

67. *Ibid.*, 490.

68. W. Kip Viscusi, "Presidential Oversight: Controlling the Regulators," *Journal of Policy Analysis and Management* 2 (1983): 157-173, page 162.

69. *Ibid.*

70. See Glen Nager, "Bureaucrats and the Cost-Benefit Chameleon," *Regulation* 6 (Sept./Oct. 1982): 37-42.

71. Burke Zimmerman, "Risk Benefit Analysis: The Cop-Out of Government Regulation," *Trial* (Feb. 1978): 43-44.

DECISION FRAMEWORKS TO ENHANCE OCCUPATIONAL HEALTH AND SAFETY REGULATION

Judith R. Lave* and Lester B. Lave**

February 1983

Draft report done for Office of Technology Assessment. Do not quote or cite without written permission of authors.

* Graduate School of Public Health, University of Pittsburgh
** Graduate School of Industrial Administration, Carnegie-Mellon University

Table of Contents

I. Introduction 1

II. Social Goals for Risk Management 4
- a. Economic Efficiency 4
- b. Equity 4
- c. Administrative Simplicity 5
- d. Acceptable Risk 6

III. Alternative Decision Frameworks for Managing Risks 6
- A. Nonregulatory Methods 7
  - Market Management of Risk 7
  - Torts 7
  - Collective Bargaining 9
- B. Process Oriented Framework 9
- C. No-Risk 10
- D. Technology Based Standards 11
- E. Risk-Risk 14
- F. General Balancing of Risks Against Benefits 15
- G. Cost-Effectiveness 16
- H. Regulatory Budget 16
- I. Benefit-Cost Analysis 17

IV. Implementation of Frameworks 19
- A. Required Information and Analysis 19
- B. Quantification of Risk 19
- C. Priority Setting 20
- D. How Safe is Safe Enough? 21
- E. Implementation of Regulations 21

Performing a Benefit-Cost Analysis 22

Implementation Difficulties 26
Identification and Classification 27
Measurement 28
Quantification 28
Aggregation 29
Comparing the Health Stress 30
Making Effects Comparable Over Time (Discounting) 32
Valuation of Premature Death 35
The Human Capital Approach 35
Willingness to Pay 37
Adjusted Willingness to Pay 38

VII. Reexamination of Recent Occupational Health Regulations 41
Coke Oven Gases 42
Benzene 47
Vinyl Chloride 52
Brown Lung Disease 56

VIII. Conclusions 61

APPENDIX: Significant Risk 64

IX. References Cited

I. Introduction

Industrial production began in an era which did not conceive of the government's setting work conditions. Occupational safety and health were left to the knowledge and good will of the employer, the self-interest of the worker, and the courts, should the worker suffer injury and subsequently sue his employer for negligence. Even absent benevolent feelings toward employees, the employer has some investment in them because of their experience and on the job training; thus he would be motivated to provide at least some minimal level of safety.

By the end of the last century, it was evident that these private decisions were producing far too many accidents for the good of society. The result was state workers' compensation laws that required employers to pay the medical costs and replace lost income (subject to a limit) associated with any accident occurring in the workplace, no matter who caused it. This system helped both to reduce the number of accidents and to increase productivity (Ashford 1976, National Commission 1973). However, between 1910-1920 when the statutes were enacted and the present, compensation levels have been eroded by inflation. They are no longer viewed as providing satisfactory compensation by most workers and by society more generally. In addition, the statutes, agencies, and courts have never dealt effectively with occupational disease.

Workers' compensation replaced a system that allowed an employee to sue his employer for negligence (Baram 1982). These suits did not work well in the sense of providing adequate, timely compensation to the majority of injured workers. Evidence of the current unsatisfactory compensation level under workers compensation is the increasing tendency for workers to sue third parties (since they are forbidden to sue their employers under workers' compensation). For accidents and occupational disease (such as those related to asbestos), juries seem willing to award workers large amounts to supplement their workers' compensation payments.

Between 1961 and 1970, the reported rate of occupational accidents increased 29 percent. Prior to 1960, there had been a steady decline in the reported occupational accident rate. Congress deemed it essential to create a federal regulatory agency that would not only provide incentives (as did workers' compensation), but also would directly regulate health and safety conditions. The Occupational Safety and Health Administration was conceived of as an agency that would address health and safety issues without relying on other institutions, such as workers' compensation, worker suits, and collective bargaining.

Unfortunately, OSHA's performance has not been satisfactory (Zeckhauser and Nichols). Its own as well as independent evaluations conclude that it has not had a discernable effect on accident rates (DiPietro, Smith, Mendeloff). Aside from prior standards that were adopted by the new agency, OSHA has only managed to regulate a total of 18 carcinogens, and a handful of other toxic substances. It has had little effect on occupational disease. Developing new regulations has required several years, thousands of professional days, and prolonged litigation. These delays are inherent in current court interpretations of the Administration Procedures Act and there seems little prospect for being able to promulgate regulations more quickly and easily.

This report does not attempt to address OSHA's problem directly. Rather, it is directed toward exploring a range of alternative frameworks for deciding about regulations. It sets out a number of frameworks currently in use as well as some proposed ones. Criteria are specified for evaluating each framework. We then describe some of the difficulties of implementing the frameworks. Finally, we examine four recent occupational health regulations and apply the various decision frameworks to each. This exercise provides perhaps the best characterization of what would be the implication of each decision framework in practice.

While we have attempted to set out the decision frameworks in an even handed fashion, we see the primary problem facing OSHA as having to increase the economic efficiency implications of their decisions. Thus, some of the frameworks appear to offer no improvement while some others hold out hope.

II. Criteria for Evaluating Social Programs

Social programs, particularly governmental programs, are designed to accomplish a set of goals. To evaluate a program, one must determine the extent to which it has accomplished its goals and at the same time whether it did so efficiently (using the least resources), enhanced social equity (although it is difficult to define equity), and was administratively simple.

The particular case at hand is the evluation of social programs for controlling risk, particularly occupational risk. The goals are reducing the risk to the group at issue from the class of hazards under scrutiny. Thus, the evaluation criteria would be the extent to which a program reduced risk, whether it was efficient in what it accomplished, whether the program was equitable, and whether the remaining risk was considered to be acceptable.

a. Economic Efficiency

This criterion refers to the total amount of resources used to accomplish a particular goal. When one risk management program requires less resources than another to achieve the same level of safety, the former would be said to be more efficient. Economists have various tools for measuring static efficiency (efficiency assuming no change in conditions, such as technological advance) and dynamic efficiency (resource use over time assuming that research and development are possible and that consumers and producers will react to the program). Choosing an efficient program for risk management means that resources will be saved for accomplishing other social goals, such as risk reduction in other areas. Dynamic efficiency is particularly important since bad decisions today could mortgage our future. There is some indication that environmental and occupational regulations have slowed measured productivity increase and innovation. The estimated effect is small and may be an artifact of how national income is measured (taking no account of an enhanced environment and little account of occupational health and safety). Nonetheless, if occupational regulation did slow productivity growth and innovation, it could impose high long term costs on the economy (Denison, 79).

b. Equity

A risk management proposal that had the effect of increasing risks to those already at highest risk while decreasing risk for the rest of society would be perceived to be inequitable. Similarly, a vast increase in the risk to future generations in order to achieve a tiny risk reduction for the current generation would be considered inequitable. While equity is an important goal, there is little agreement on what constitutes equity (MacCarthy, Connerton and MacCarthy). There are some general principles, such as that the one who benefits should pay and that those at highest risk ought to be the first recipients of risk reduction. However, these principles are vague and often contradictory. One is left with recognition that equity is important, that people are likely to feel strongly about equity in most cases, and that often people will be in disagreement on what changes would enhance equity (Fischhoff et al.).

c. Administrative Simplicity

Administrative simplicity means minimizing the red tape or government and private burden of implementing and enforcing a program. Since programs can easily be strangled by red tape, it is important to anticipate the problem and keep the program simple.

No terribly complicated program is likely to succeed. A society with 230 million people, tens of millions of production facilities, 100 million workers, and a vast diversity in products, jobs, and risks will inevitably have different reactions to a risk management proposal. Even the simplest of programs will become complicated in attempting to deal with these different circumstances.

Governmental programs must appear plausible and likely to be successful. If those regulated cannot understand the program or if they believe it will fail, then inevitably, it will fail.

d. Acceptable Risk

A final test is whether the remaining risk is considered acceptable. Presumably, a program could meet all of the above criteria, but impose an unacceptable risk on some group and thus be considered unacceptable. Since our focus is on risk management, no program of risk reduction can be considered successful if it leaves what are generally perceived to be unacceptable risks for some group. Unfortunately, there is no easy way of determining if a risk will be acceptable.

III. Alternative Decision Frameworks for Managing Risks

Although regulatory agencies were given vast new responsibility in managing risk during the 1970s, the predominant means of dealing with risks have remained outside this sphere. The ways in which we conceive of risk and how it should be managed can be divided between the relatively new regulatory methods and nonregulatory methods, such as individuals decisions, the market place, the courts, and collective bargaining. Each approach to risk management, each decision framework, influences how we perceive the situation and what sorts of solutions will be offered. Much is to be learned from a historical examination of why society chose to handle a particular class of risks with a particular decision framework. This decision tells more about the deeply held goals than the rhetoric in speeches or statutes. An investigation of these decision frameworks is essential to our attempts to improve risk management. Knowing how each framework performs should allow evaluations of new proposals for managing classes of risk.

Each of the regulatory frameworks can be viewed as a special case of benefit-cost analysis with some specialized assumptions about the nature of uncertainty in the analysis or about values. For example, the "no-risk" framework assumes that, in that particular case, only human health matters or that it is impossible to quantify costs and other effects with sufficient confidence to be useful to the analysis. Thus, the choice of a framework is implicitly a statement about both uncertainty and social values. However, the choice of framework seems a felicitous way of specifying those values and uncertainties.

The frameworks can be ordered, roughly, in terms of the amount of information and analysis required by a government agency to implement each: nonregulatory methods and the regulatory methods in the order presented.

A. Nonregulatory Methods.

Until recently, virtually all risks were managed without regulatory intervention. A number of institutions were developed to manage risk and a much greater number of institutions were modified to deal with risk more effectively (Baram, 1982).

Market Management of Risk. In a world of perfect competition, no externalities (interactions among economic agents outside the market, such as polluting the air or water) and full information, market equilibria will be efficient (Pareto optimal) in the sense, that no rearrangement of production or distribution could make anyone better without making someone worse. Under stringent assumptions, this efficiency property also holds for allocation of risk owing to hazardous products, services, or jobs (Arrow). In particular, all workers and consumers are assumed to know the risks as well as the other attributes of each job and product; also, there must be markets that provide the relevant array of safety and quality attributes in jobs and products to choose among. In addition, workers and consumers must make insurance decisions that protect their dependents if accidents or disease occur. In such an idealized world, each consumer and worker would consult his feelings about risk and select an occupation and set of products that maximize utility: producers would examine the price premias consumers were willing to pay for safe products; and they would examine the wage premium they would have to offer for relatively unsafe jobs. They would be motivated, and would have sufficient information to modify the mix of jobs and products offered so as to maximize simultaneously profit and achieve the socially correct safety levels (see Oi, Smith, Thaler and

Rosen). Under these restrictive assumptions, there would be neither necessity nor role for government regulation.

Clearly, our economy does not satisfy the restrictive assumptions; externalities abound, often both buyer and seller are woefully ignorant of the health and safety implications of a product, the full range of safety in jobs and products is not offered and people do not have the ability to choose adequate insurance for their dependents. Under these conditions, the market equilibrium is not efficient (Pareto optimal) and a case can be made for government intervention.

However, government intervention also brings costs and inefficiencies unrecognized in simple theory. Regulation requires resources; but more important, it is virtually impossible to regulate so that incentives are not distorted, often leading to even greater inefficiency than exists in the unregulated market (Schultze), for example, transportation regulation, particularly of airlines (Keeler, 1978). Many economists have concluded that regulation is justified only by "serious" violations of the assumptions, and only then if the regulation can be relatively efficient. Regulation should be decided on an ad hoc basis, depending on the nature of consumer and worker ignorance and magnitude of risk. Whether to license auto mechanics or regulate sodium nitrite is decided by appeal to the specific facts and risk, rather than being settled by theoretical proofsQ that we ought to regulate all risk situations or none.

Torts. Safety of products and of the workplace are influenced by the ability under the common law and various statutes to sue a manufacturer or employer if he is negligent or provides an unreasonably risky product or work environment. For occupational health, until recently, the advantages lay with the employer. However, recent court cases have shifted the balance toward workers. Awards far in excess of $1 million have been made to those injured; they have influenced safety decisions.

Collective Bargaining. When workers perceive an unreasonable risk to their health and safety, they can bargain collectively about those conditions just as they do about wages. To date, wage issues have had first priority and safety has been neglected. One might interpret the political stance of unions as attempting to remove safety from the bargaining table. By making safety a government regulatory responsibility, unions are free to focus on wages and not to have to contemplate an explicit tradeoff of wages for safety.

Voluntary Standards. For many years, industry and other groups have established standards designed to protect consumers and workers. Standards were proposed, considered, and action taken. While not binding on any manufacturer, there is pressure to comply.

Other Nonregulatory Methods. Other institutions exist to control risk. These include insurance, licensing of occupations and places of business, building inspections and building codes, and design specifications generally. For most of these, the primary goal of the institution is not risk reduction. For example, the primary goals of insurance is to protect against financial loss. However, insofar as insurance premiums reflect the risk level, people will be motivated to reduce risk in order to lower their premiums.

These nonregulatory methods all avoid government standard setting and enforcement and remove the regulatory agencies from the interactions between manufacturers and consumers or employers and workers. They implicitly assume that regulatory action is unnecessary, or at least not the most efficient or effective way of setting and enforcing the desired level of risk in society. In view of the growing disillusionment with the capacity of government to solve all the problems it sought to resolve, these methods are worth greater attention. In some cases they are superior to regulation, even though they don't solve the problem. More importantly, the institutions can be changed to make them more effective by, for example, mandating labeling and information dissemination.

Regulatory Frameworks

For many social hazards, Congress decided that there nonregulatory frameworks were doing an inadequate job. For example, early in this century Congress created the Food and Drug Administration to lessen some of the hazards in these areas. More recently, Congress has acted to create regulatory agencies for mine safety, occupational safety and health, highway safety, environmental protection, and consumer products. In many cases, the agencies started with the mission of doing research or providing information. However, the mission shifted to giving the agency responsibility for setting and enforcing standards to reduce hazards.

In each case, either Congress gave the agency instructions regarding goals and methods or the agency developed these under Congressional oversight. Unfortunately, the goals are rarely clear or unequivocal. Rather, they tend to be general and contradictory. For example, the Occupational Safety and Health Act instructs OSHA to "set the standard which most adequately assures...that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life." This goal of providing absolute protection to the employee is later tempered by the notion that the standard must be feasible, both technically and economically.

Generally, more is to be learned about the goals of Congress and of the agency by examining the implications of the decision framework each adopted than by examining statutory goals. We briefly characterize seven decision frameworks. Five of these are currently used by regulatory agencies. Two have been proposed by agencies or by Congress.

No-Risk. The no-risk regulatory decision framework is exemplified by the Delaney Clause of the Food, Drug and Cosmetic Act. Congress instructs the FDA to prevent the addition of any carcinogen to food (Merrill, 1981; Hutt, 1978). No risk of getting cancer from a food additive, no matter how small and no matter how great the benefits of the additive, is considered acceptable. No improvements in the appearance, taste, and convenience of food are sufficient to justify even the smallest risk of cancer.

Similarly, the Clean Air Act Amendments of 1970 instruct the U.S. Environmental Protection Agency (EPA) to set primary air quality standards that protect the public health (presumably even of the most sensitive people). These statutes embody the notion that no risk is acceptable, even one that is miniscule. According to these statutes, if the agency uncovers a nonzero risk in the designated area, it must set it to zero by banning a product or activity or otherwise ending the risk.

The U.S. Supreme Court in the benzene decision draws attention to an obvious fact: All human activity involves risk. People willingly assume greater risks in order to increase their income, increase the appeal of consumer products including food, and even to increase their pleasure in recreational activities. While "no-risk" has appeal as rhetoric, it is a pernicious guide to regulatory decisions.

While a uniform attempt to achieve zero risk must fail, society could focus on a number of cases, such as carcinogenic food additives, and insist on zero risk. However, as Congress' decision not to allow the FDA to ban saccharin demonstrates, there is no agreement that no-risk is a desirable goals for all food additives.

Technology Based Standards. This decision framework requires a regulatory agency first to identify a risk and then to reduce it to the extent technologically feasible. Interpreted literally, technology based standards require utilization of the best available control technology without regard for costs or effects. This framework has been the basis of EPA's water regulation and has played an important role in air regulation, particularly the control of new sources. By neglecting all aspects of the decision except technological feasibility of control, Congress spared EPA from having to deal with the difficult issues, such as having to decide how much control is socially desirable given its cost and disruptive effects.

In practice, the best available technology is never required. The language is meaningless. Virtually any standard is technically feasible (using elaborate control technology or banning the substance), although the cost could be so high it might mean the company will be bankrupt.

Instead, in practice, technical feasibility is interpreted through "engineering judgment." That judgment is not justified or analyzed, but simply stated as being based on experience. Different experts arrive at different estimates of feasibility, based on their judgment as to what technology is available and what is a reasonable cost. EPA has a number of different concepts of technology based standards: best available control technology, new source performance standards, least achievable emissions rate, etc. Each concept implies a different weight for cost in the engineerng judgment.

OSHA and the courts interpret its statutory requirement of "feasibility" to mean a standard must be both technologically and economically achievable. For toxic substances generally, and particularly for carcinogens, OSHA selects a concentration standard that corresponds to the best control technology, subject to economic feasibility.

For OSHA, economic feasibility is stated in terms of the viability of the industry, even though individual firms may go bankrupt. This whole notion is vague. The adversarial nature of the regulatory review process (for any decision framework that allows their consideration) guarantees that firms will attempt to misrepresent the cost and other burdens imposed by each standard. No one can estimate with any degree of assurance what the effects will be. Analyses have often been no more than surveys of the opinions of industry executives plus some back of the envelope calculations. This could be done much better.

Economic feasibility creates inequity. A standard set during a period of profitability would be more stringent than one set during a lean period. Since the standards are rarely changed, the level of safety would depend on when the standard was set. Furthermore, the profitability of an industry will affect the stringency of standards specific to it. We believe it is inequitable that workers in a profitable industry, or during a period of profitability, should be better protected because of government regulations than workers in a marginal industry. Similarly, currently unprofitable industries such as steel should not be allowed to pollute the air or pose unreasonable risks to workers. The first social question is: How clean do we want the air and how safe do we want workers? Having decided that, we should worry about how to achieve the goal. Achieving the goal might require subsidizing the industry, if the standard is not economically feasible and we do not want to see the industry go bankrupt.

A federal appeals court recently noted these issues: "We view the (Occupational Safety and Health Review) Commissions' interpretation of 'feasible' as a reasonable reconciliation of the regulations' language and the (OSHA) statute's 'reasonably necessary' requirement. In requiring employers to implement economically feasible engineering controls, the regulation would require only those controls that are 'reasonably necessary and appropriate' to protect employees' health and safety. The Commission has concluded that a control is not reasonably necessary and appropriate if the benefits to be gained by employees do not justify the cost. This interpretation of section 3(8) is neither unreasonable, arbitrary, nor an extension of the authority granted the Commission by the Act.

"The Secretary (of Labor) warns that approval of the Commission's test of feasibility will undermine the central goal of the Act, which is 'to assure so far as possible every working man and woman in the Nation

432

safe and healthful working conditions...'. We disagree. The test of feasibility advanced by the Secretary, that controls are infeasible only if they threaten the employee's financial viability, offers less protection to the worker than does the Commission's approach. It conditions employee health and safety on the employer's financial viability and thus arguably exempts some employers from providing necessary protection. The Commission's test emphasizes benefits to be gained by employees and does not excuse or exempt marginal employers who cannot adequately protect employees. At the same time, the Commission's test provides a realistic view of the range of hazards from which employees require protection and the alternate means of providing that protection, and recognizes that the Act does not 'require employers to provide absolutely risk-free workplaces whenever it is technologically feasible to do so...". (Donovan v. Castle and Cookie Foods and OSAHRC, Ninth Circuit, 10 OSHC, p. 2175. Footnotes omitted and emphasis added.)

In another case (Boise Cascade Corporation), the Ninth Circuit Court of Appeals reinforced its Castle and Cooke decision, although the language is less clear than that stated above. However, in a ruling seven days after the Boise Cascade decision, the Occupational Safety and Health Review Commission "...respectfully decline(d) to acquiesce in the Ninth Circuit's divergent interpretation of the term 'feasible...(definition of 'feasible' as economically and technologically capable of being done...)." Thus, the Department of Labor, particularly the Occupational Safety and Health Review Commission has set up a confrontation that must be decided by the courts.

The equity issue arises largely because it is government regulation that is assuring differential protection to workers. Were the difference due to market forces, the government could assure that all workers received at least a minimum standard of protection. What is objectionable is having government set and enforce safer standards for plastics workers than for cotton mill workers.

Risk-Risk. Having identified a risk, this framework requires an agency to weight both beneficial and adverse health effects in attempting to reduce the risk. The framework was proposed by the U.S. Food and Drug Administration (FDA) and Department of Agriculture because the Delaney Clause appeared to require banning a food additive, thereby costing more lives than it would save (FDA-USDA, Green, 1978). Some toxic substances, such as food additives and fungicides, protect our food against contamination. Their use requires balancing the good they do in expanding the food supply and lowering its cost against the inherent toxicity of each substance. Even if someone believes that health is paramount and that no risk would be justified by an expansion of the food supply or decrease in its cost, in these uses one would still need to balance health protection against the toxic effects of each substance.

One version of this decision framework is to limit consideration to the health risks and health benefits to each individual. For example, FDA and USDA proposed that the health benefits of sodium nitrite (protection against botulism) to the consumer be considered along with the health risks (cancer) to the consumer. This limited version, direct risk-risk analysis, is not useful for occupational risks since rarely, if ever, does a toxin offer a direct health benefit to the worker.

The more general version of this approach is the indirect risk-risk framework (Lave, Morris, Collingfurdang, Niehans). One might argue that all workers are also consumers and, in the USA in 1983, virtually all consumers are also workers for a large proportion of their lives. Thus the risks to workers and consumers should be considered together. In particular, OSHA should be attempting to minimize the sum of worker and consumer risks. If so, mandating additional construction or equipment to safeguard some workers may cause accidents to other workers. Similarly, EPA regulations designed to protect consumers may increase risk to workers. This indirect risk-risk framework would attempt to minimize the sum of worker and consumer risks.

F. General Balancing of Risks Against Benefits

The three previous frameworks do not allow consideration of nonhealth effects, such as employment or wage rates. The folly of refusing to consider these effects is illustrated by examining our own choices. For example, most of us are willing to take risks in our work, such as traveling to meetings. We even assume such risks when it is strictly voluntary.

The risk-benefit framework attempts to consider both risks and benefits associated with any choice. Only after weighing one against the other is a decision to be made. This framework proposes to account for cost, convenience, and even preferences in an attempt to balance these against risk (Starr, 1971; NAE, 1972; Hutt, 1978; Merrill, 1981; Clark and Van Horn, 1978). Unfortunately, risk-benefit is used loosely to describe a vast array of frameworks, from narrow conceptions of balancing benefits against risk to general handwaving. The framework has an immediate appeal to Congressmen and regulators since it is a vague instruction to consider all social factors in arriving at a decision. While no one can oppose considering all relevant factors, no one has specified how to operationalize this framework.

G. Cost-Effectiveness

Cost-effectiveness analysis attempts achievement of some goal given the constraint of a fixed budget (Hitch and McKean, 1965). When more than one program will achieve the goal, this framework searches for the cheapest one. In cost-effectiveness analysis, one tries to get some comprehensive measure of benefits, perhaps in units of health, and some comprehensive measure of costs, perhaps in dollars. However, no attempt is made to translate the health units into dollars so that a net social benefit can be computed.

Formal development was closely associated with the Department of Defense; the goal was paraphrased by President Eisenhower's Secretary of Defense, Charles Wilson, "Get the most bang for the buck." Most organizations must live within a fixed budget for the next planning period, and so this framework poses the correct question. More importantly, almost all organizations, other than those directly producing some good or service, cannot measure their output or contribution to the institution they serve; their budget is determined by some informal process encompassing past expenditures, perceived contribution, and current availability of funds. When budget is not directly related to current output, cost-effectiveness is the relevant framework for guiding actions.

H. Regulatory Budget

This framework is a particular way of implementing cost-effectiveness (DeMuth, 1980a, 1980b). Congress would set a budget for each regulatory agency determining the total costs that implementing its actions could impose on society. At present, few regulatory agencies face any constraints other than the time of their staff and their ability to defend their actions in litigation. The regulatory budget would provide an additional constraint. Each agency would have to consider the costs it imposes on the economy in addition to trying to enhance health and safety. Given its goal and two budgets, cost-effectiveness would be used.

There is much to be said for this framework. It poses an understandable constraint on the agencies and asks Congress familiar questions. Without doing anything so objectionable as requiring that the agencies or Congress state the amount society should spend to avert a premature death, it provides a constraint on the agencies. Most importantly, the framework puts pressure on Congress and the agency to clarify their goals, attack the most important problems first, and to use society's resources efficiently.

Implementing this framework would be difficult. It is extremely difficult to estimate the cost to an industry of a particular regulation; one could be confident that each agency would select a cost estimate at the lower bound of credibility, or even below that; the regulated industry would select a cost estimate at the upper bound of credibility. However, the most important virtue is that this framework poses the proper question in a felicitous fashion, one that is familiar and acceptable to both the agencies and Congress.

I. Benefit-Cost Analysis

The best developed, quantitative framework for analyzing regulatory decisions is benefit-cost analysis (Prest and Turvey, 1966; Mishan, 1976). It asks for a full specification of the social effects of a proposed action, quantification of these, and then a comparison of them using dollars as a common metric, so that the net social effect can be estimated. One of the most controversial aspects of its application is putting an explicit dollar value on the cost of premature death, or rather on the value of prolonging life (Linnerooth, 1979); another is the social rate of discount (Baumol, 1980).

Some economists advocate this framework as the sole basis for making decisions. If so, every effect must be identified and quantified, even though some are better quantified and evaluated. One can conceive of incorporating into the analysis effects as nebulous as redistribution of income or extinction of a species, but in practice there is no hope of doing so in a way that would be widely accepted.

While benefit-cost analysis is not the only basis for decision making, it is an important input. The scientific facts are invariably incomplete, but they indicate what is known, what has been disproven, and what is being conjectured. Although incomplete, benefit-cost analysis provides an important input to decision making since it stresses what is known and measurable.

Other Frameworks. A number of other decision frameworks have been used or suggested, including the legislative veto and negotiation. The former has been used by Congress hundreds of times and involves subjecting an agency decision to veto by a legislative process less comprehensive than the passage of a bill by both houses which the president then signs. According to Scalia, legislative veto is unconstitutional because it violates the procedure defined by the constitution for congressional action. A Supreme Court decision this term will provide more definitive evidence of constitutionalty. Even were it constitutional, legislative veto would be a bad idea since Congress does not possibly have sufficient time to review all agency decisions. Rather, the proper role of Congress is to set out the correct goals and constraints on an agency and review, along with the courts, whether an agency is correctly following the rules.

The idea of brining all parties together to reach agreement comes from examination of health and safety decision in places such as Japan and Sweden (Reich). However, these are smaller, more homogeneous societies with less confrontational traditions. However well this method works in other countries, it is unlikely to be successful in the USA. Or rather, its success in the USA is contingent on all parties accepting the goals and constraints defined by Congress and then working out the best way of implementing them.

IV. Implementation of Frameworks

In applying these frameworks to particular examples, a series of issues arise. A few are settled by the assumptions of a framework, but almost all require painstaking research and policy analysis.

A. Required Information and Analysis

The frameworks differ markedly with respect to the amount of information and analysis required, and to who must gather the data and perform the analysis. Often important information is not available or is exorbitantly expensive to collate and analyze. What methods should be used for quantifying risk and how much confidence can be placed in each (Lave and Seskin, 1977, 1977; Lave, 1981)?

The nonregulatory frameworks require decentralized data collection and analysis, often by individual workers and consumers. However, each individual does not need complete information to arrive at good decisions. While this process seems costly, it gets information to the most important decision maker and thus starts to shape behavior.

The regulatory frameworks differ in their information requirements, with no-risks needing the least and benefit-cost needing the most. The cost and time required for information collection can impose heavy burdens on an agency.

A related difficulty is that, at present, agencies are often not purposive in the information they develop. Data are not available on a timely basis. Often there is a concentration of resources on questions that researchers want to pursue, rather than on those central to the agency's mission. A careful specification of the decision analysis framework would reveal what data are required and help improve the quality of agency decision making.

B. Identification and Characterization of Risk

At present, most agencies are reactive, dealing only with cases brought to then. Such firefighting does not allow the agency to set priorities and attack the most important problems first. To develop a more rational agenda, each agency must identify the hazards under its purview and gain some rough idea about the importance of each. This risk characterization must be done quickly and at low cost (Lave, Omenn, Hofferman, and Dranoff).

C. Quantification of Risk

The frameworks from risk-risk through formal benefit-cost analysis require quantification of risk (Hoel, 1974; Crump, 1979; Crandall and Lave, 1981; ILRG, 1979; BEIR, 1972). A large literature on risk quantification encompasses many fields (Lave, 1981a). While risks can rarely be estimated with confidence, methods are available and the resulting risk estimates provide insights for regulation.

Some authorities have asserted that quantification cannot now be done with sufficient confidence to be the basis of regulatory decision making. Epidemiological data are rarely complete or totally relevant to the regulatory decision; they may reflect a much higher exposure level or the exposure level may be unknown. Extrapolating from rodents to humans, from different exposure routes, and from high to low doses is inherently difficult. Rarely do rigorous models exist that explain and justify such extrapolation. Some scientists react to these difficulties by refusing to make any quantitative risk estimates.

Both deriving a single risk estimate and ignoring aspects of the problem are unsatisfactory. They lead to unwarranted confidence in the outcome of the analysis, do not promote the needed research and data collection, and lead to policy recommendations less informed than they need be. The alternative is a careful modeling of uncertainty and explicit treatment within the analysis and decision making.

D. Priority Setting

Each agency must decide which issues to ignore and the order of priority for those it chooses to consider. If agencies gave more attention to setting priorities and airing them before Congress and in public hearings, they might avoid many of the past difficulties of rushing frenetically from problem to problem and being sued for neglecting problems. Frameworks such as cost-effectiveness and the regulatory budget naturally produce a priority ordering and tell the agency what to focus on each year. Others, such as benefit-cost and risk-risk analysis, produce outputs that can be used for setting priorities. Frameworks such as no-risk and technology-based standards determine what should be regulated but give no hint of priorities.

Complicating priority setting is the lack of social consensus on a set of important issues. For example, society places higher priority on protecting children than on the aged, and cancer is considered to be worse than accidental death. These judgments are used to set priorities in practice. However, they are rarely made explicit and often can be discovered only by examining regulations and enforcement priorities.

Setting priorities via analysis will be woefully inadequate without these general social values.

E. How Safe is Safe Enough?

Regulation requires setting some standard or goal. How much safety does society desire in view of the cost (Fischhoff and others, Schwing and Albers, Lawrence)? Every framework must address this issue, for example, "no-risk" proscribes any risk. Most frameworks do not address the issue so directly. There is a duality between risk level and the economic notion of cost of premature death. For example, the Delaney Clause implies an infinite value of life while any finite cost of premature death implies a nonzero level of risk. Whether the regulatory decision should be made by focusing on risk level or cost of premature death is a matter of convenience. Which notion poses the question most felicitously? Congress or the regulatory agency must set the critical parameter on the basis of their perception of society's goals.

F. Implementation of Regulations

Once an agency has formulated a regulation, it must decide how to implement it. Regulations are currently implemented by ad hoc processes of negotiation and inspection that can impose fines, shut down operations, or levy criminal penalties. The current system does not work very well (Mills, 1978; Mills and While, 1978; Ruff, 1979; Wilson, 1974 and 1980; Zeckhauser and Nichols, 1978). Economists have proposed the public use of private interest (Schultze, 1977); i.e., the use of economic incentives that redirect self-interest toward achieving what is in the social interest. For example, firms seek profit. By charging them for worker injuries and diseases, one is putting pressure on firms to lessen their incidence. In contrast, using court sanctions to achieve the goals motivates the firm to find legal means to escape the sanctions and perhaps do nothing to solve the problem. Greater reliance on voluntary cooperation or government-industry cooperation have also been advocated.

The current legally based system has some strengths but could be improved. Juries must convict the defendant and the judge must set an appropriate penalty. Trial is expensive to prepare and proof must be beyond reasonable doubt. Trial was not designed for relatively minor, frequent violations. Rather, some more simple procedure is needed. In contrast, for willful or criminal violations, a court is the proper forum for serious sanctions such as criminal penalties. Economic incentives, such as effluent fees and marketable discharge licenses, focus on economic efficiency with less concern for other factors. They cannot deal effectively with criminal violations or equity problems.

Exploration of the properties of each proposed method for implementing health and safety regulation is needed. For each regulation, we must determine which implemetation method offers the most advantages.

V. Performing a Benefit-Cost Analysis

One of the best expositions of the steps involved in performing a benefit-cost analysis is contained in an OTA report: "The Implications of Cost-Effectiveness Analysis of Medical Technology." The report lists ten steps.

The first is defining the problem. One must decide what issues are to be considered, what remedies are possible, and what are the goals. All too often, the problem is not defined adequately, resulting in confusion and poor solutions. When the problem is defined clearly, one can object that it is trivial or that the definition rules out the most important aspects or the only reasonable solution.

The second step is stating one's objective or goals. Complicated social problems invariably involve different groups and various desires of each group. Unless the goals are stated, everyone is free to argue for outcomes based on his own implicit goals. The result is generally confusion and hopeless deadlock. Since all problems and goals cannot be handled at the same time, it is important to identify what is being considered and what is the desirable outcome.

The third step is to identify all reasonable means to accomplish the stated objectives. The object of the analysis will be to determine which alternative best accomplishes the goals. Too limited a specification of alternatives will lead to choosing an inefficient solution. However, since attention is limited, it is important to stress that only reasonable alternatives are worth considering; there are an infinite number of unreasonable alternatives.

The fourth step is to analyze the benefits of each alternative. All effects of a program should be identified. Those that are desirable outcomes are benefits; the undesirable ones are costs and are considered in the fifth step. Not only must the benefits be identified, they must be measured, related quantitatively to the program, and valued in dollar terms. As discussed below, measurement is often difficult. Perhaps the most difficult step is developing the quantitative relationship. Even the seemingly trivial step of listing effects is difficult. There are virtually an infinite number of effects, direct and indirect, of a program. One needs to decide which effects are too trivial to be listed and which indirect effects are covered by consideration of the direct or other indirect effects. Valuing effects is controversial and difficult.

The fifth step is the analysis of costs. All undesirable effects must be listed, measured, quantified, and valued. This step is subject to all of the difficulties associated with the previous step.

The sixth step is to specify the perspective used in the analysis and to consider other important perspectives. In general, a benefit-cost analysis is done from the perspective of current US society. However, the perspective taken might be US society at some time in the future or some geographically defined, or culturally or ethnically defined group. Indeed, the perspective could be that of an individual. Often the perspective of a particular group, such as workers exposed to vinyl chloride, will be very different from that of society. It is often helpful to consider how the analysis would change if other important perspectives were to be used.

The seventh step is to make effects occurring at different times commensurate. This is done by discounting, as discussed in more detail below.

The eighth step is to analyze uncertainties. The prior steps, particularly 4, 5, and 7, will generate important uncertainties. These must be described and analysis performed to detail how the nature of the conclusions are sensitive to the most important uncertainties.

The ninth step is to address ethical issues. The benefits and costs will not accrue uniformly across people or over time. Inevitably, some people will reap a disproportionate share of the benefits while others incur a disproportionate share of the costs. Analysis is needed of the distribution of benefits and costs as well as of whether particular outcomes or required actions are tolerable.

The final step is to interpret the results. Neither the facts nor the analysis speak for themselves. Rather, one must provide a careful interpretation as to what one might properly conclude, what are the uncertainties and how important they are, what issues remain uncertain, and which alternative solutions seem to dominate.

These ten steps are far from trivial to carry out. A few of the steps, including the analysis of benefits and costs, discounting and analysis of uncertainty require further explication. The ten steps require expensive data collection, extensive analysis, and many value judgments. Many people object to benefit-cost analysis, arguing that the analysis involves so much arbitrary judgment, is so expensive and time consuming, and is so dependent on the idiosyncracies of the analyst that there is little or nothing to justify the recommended outcome.

A formal benefit-cost analysis that encompassed these ten steps and involved full dollar estimates of benefits and costs and a computation of net benefits is an extreme analysis. It can be thought of as one anchor in a continuum of possible forms of analysis or frameworks for scrutinizing policy issues. The other anchor point might involve choosing the first alternative to come to mind. A less arbitrary alternative might involve defining the problem, stating objectives, and then listing all benefits and costs. Not having to measure, quantify, value, or discount benefits and costs eliminates the controversial aspects of the analysis. However, having long lists of benefits and costs with no way to assess their importance is of limited use or possibly dysfunctional. The inevitable result is that the policy maker will make some implicit, subjective judgment about the importance and magnitude of each effect in arriving at a solution. It is better to have the analysis set out its assumptions where data are missing or values are involved. However arbitrary and difficult is the formal analysis, it is likely to be more defensible and helpful that this implicit, subjective assessment.

A framework closer to benefit-cost analysis would involve the measurement and quantification of all benefits and costs, but not attempt to put benefits and costs into comparable units. In cost-effectiveness analysis, one tries to get some comprehensive measure of benefits, perhaps in units of health, and some comprehensive measure of costs, perhaps in dollars. However, no attempt is made to translate the health units into dollars so that a net social benefit can be computed. Instead, one computes the cost-effectiveness or ratio of benefits to cost for each alternative. One alternative is then said to be the most "cost-effective" because it gives health units at the lowest cost.

One value implicit in this analysis is that we always prefer to accomplish an objective at lowest cost. Thus, in structuring alternative policies, we build up components that attain the desired objectives at least cost. This preference is only the simplest form of cost-effectiveness analysis.

The OTA report distinguishes between the use of ten steps to generate a recommended policy and the use of the ten steps to clarify the nature of the problem and the policy alternatives. Executive Order 12291 not withstanding, it is evident that uncertainties prevent identifying a "correct" solution. The difficulties in measurement and quantification, in choosing discount rates, in valuation, and in sorting out ethical issues undermine confidence in any one alternative. Thus, few analysts believe that one should apply these ten steps mechanically and recommend the policy with the greatest net benefits. Yet, there are few analysts who do not agree that these ten steps are extremely valuable in achieving better solutions.

We now proceed to consider a few of these steps in greater detail.

VI. Implementation Difficulties

A complete benefit-cost analysis requires that each of the 10 steps listed above be accomplished. The first three, defining the problem stating the goals, and identifying alternatives are steps required by all the regulatory policy frameworks from no-risk to benefit-cost analysis. These steps are so fundamental to sound policy analysis that their importance cannot be over emphasized. These steps are relatively straightforward and we will not discuss them in more detail. Here we focus on the more controversial and difficult steps: steps 4 and 5 (the analysis of benefits and costs which requires the identification of program effects, the classification of effects as benefits or costs, measurement of effects, quantification, and then valuation) and step 7, the discounting of effects which take place in the future. We consider each of these elements in turn. As, the primary purpose of health and safety regulation is to improve health, most of the discussion will focus on the health benefits.

A. Identification and Classification of Effects

Any program under consideration to improve workers' health and safety will have a number of effects. As noted above, identifying these effects is not simple. Eventually an action will have ripple effects that encompass all of society. Judgements must be made as to which effects are trivial and unworthy of consideration and which effects are simply a reiteration of ones already listed. One must be imaginative enough to encompass all effects viewed as important, such as implications for the environment, endangered species, and future generations. A good deal of judgment and experience is required for this first, seemingly simple element.

The simplest procedure for classifying effects is to regard all desirable effects as benefits and all undesirable effects as costs. Thus, if a program seeks to lower workers' exposure to coke oven gases through controlling leaks, the benefits would include improvements in health while costs would include the additional resources needed to lower exposure as well as the additional administration. If the program sought to lower workers' exposure to coke over gasses through the use of protective masks, benefits would include the improvements in health while the costs would include not only the cost of the masks, but the cost of the workers' increased discomfort, as well as the additional resources that may be required to ensure that workers actually wore their masks.

Measurement

Having listed the effects of a particular program, some method must be found to characterize and measure each one. In some cases, the units of measurement are obvious: the dollar to represent the resources cost of an investment required by the program; dollars to measure the decrease in hospitalization as a result of the decrease in morbidity attributable to the program; and decreased death rates and work loss days to measure the increased number of productive days.

A program, however, may have some health effects which are difficult to measure or even to characterize. As a result of lowered injury rates, there may be a reduction in pain and suffering, retention of the use of a limb that would have been severed, the ability to move freely and easily. A disability day can be one where movement is restricted or one filled with pain. Later, under the heading of valuation, we take up this issue again.

Quantification

The next step in the analysis is to relate each effect to the program, so that estimates can be made about the magnitude of the effect of the program. For instance, one wants to know not only whether a particular program would have any effect on the worker's health, but also what the size of the effect is. For instance, suppose the standard for noxious gasses were set at 1 ppm, rather than 10 ppm. How much would each standard cost to implement? What would be the reduced mortality rate? What would be the reduction in morbidity rates? What would be the reduction in medical care costs? To do this analysis, one has to understand something about the quantitative relationship between the level of the hazard (the nature of the hazardous equipment, the noxious chemicals, the noise level) and the workers' mortality and morbidity rates.

This step is extremely difficult. Little of modern toxicological research or medical research is oriented towards providing quantitative measures of its sort. Most research is directed towards determining whether qualitative effect exists. Does this chemical cause cancer? Does this treatment help patients? The step is controversial because people hold different views about risk (and the value of life). If any death due to a controllable hazard is considered one too many, then the only appropriate regulatory framework is no-risk, and the only decision is finding the cheapest way to set that risk to zero.

All of the regulatory frameworks which make quantitative comparisons, from cost-effectiveness analysis to benefit-cost analysis, require some information on the quantitative relationship between the level of the hazard and workers health (variously defined). Without such data, it is almost necessary to resort to strive to reduce exposure to the lowest level technologically feasible, given that the initial health risk was considered significant. As shown in the next section, bad regulations are often implemented when this quantification has not taken place.

Since we believe that the more complicated regulation frameworks are likely to lead to better decisions, more research is needed on quantitfying the relationship between the level of the hazard and workers' health. The better the information and the more that is known about the risk factors, the more additional alternatives to lowering risks can be considered. If only workers with certain characteritics are subject to risks (smokers and asbestos), then regulations can be directed toward them. Without such information, it is likely that regulations will be subject to successful challenge by various interest groups. In many of these cases, the stakes are large, both in terms of possible health effects and in terms of the costs of lowering exposure. In such cases, arbitrary, uninformed decisions will generally put the regulatory process in disrepute and may actually lower occupational health levels.

Aggregation

Having listed, measured and quantified the effects of the program, the next step is to reduce the value of information by aggregating all costs and all benefits (in whole or in part). Some aggregation is necessary because it is difficult to assess a particular program or to compare alternative programs to lower a given risk by examining lists of effects. For those effects that are easily measured in dollars--implementation costs, protective clothing costs, reduced medical care costs—one simply adds up the total discounted (see below) value of the benefits and the total discounted value of the costs. However, for the most important benefits of a worker health and benefit program, aggregation is more controversial. Two types of aggregation are necessary: aggregation across individuals and aggregation across effects. In addition to aggregation, the issue of valuation and monetization of these effects must be addressed.

Aggregation Across Individuals: Consider two programs designed to prevent premature deaths. Each will save one individual: one program will prevent the premature death of a 30-year old widower with four young children, while the other will prevent the premature death of a worker approaching retirement. Are the two programs considered comparable? (See Mendeloff, 1982, for a discussion of these issues.)

Aggregating effects across individuals, regardless of how it is done, has implicit value judgments. There is no magic technique for making the value judgments uncontroversial. The best way to proceed is to make sure that the value judgments embedded in each choice are made clear.

Aggregating Health Effects

Occupational health and safety programs will have a host of effects, including changes in mortality rates, disability days, and life expectancy. As noted above, these should all be identified and measured and note taken as to when in time the effects take place. The question is how to aggregate those effects. The mortality rate of current workers at the end of 100 years will be 1.0. Thus, a program cannot lower the ultimate mortality rate of workers, but only put off the date of mortality. One measure of the health benefit is the increase in life expectancy. A variation of this measure is the number of life years gained.[1]

More subtle measures are needed to aggregate the effects of the program on the incidence of chronic and acute disease and especially on decreasing worker disability. The simplest measure is the decrease in disability days. But this measure does not describe the type of disability day averted nor is it easy to aggregate the decrease in number of disability days with the increase in the number of life years gained. One way around this problem is to construct a measure of "quality life years" (Mendelhoff, 1982). The basic idea behind this is the effort to measure health status.

The purpose of a health status index is to measure the health state of a group of individuals. The scale is usually set with defined limits where 0 would be death and 1 normal, healthy life with all functions. Various states of disease and disability are represented by numbers between 0 and 1. The intermediate conditions reflect limits of mobility and physical and social activity. The best known health studies measures are the Sickness Impact Profile (Gibson, et al., 1975, Bergner et al., 1976) and the Health Status Index (Kaplan, Bush and Berry, 1978). See (Policy Analysis, Inc., 1981, for a review).

The development of health status indices permits, as noted above, the development of a quality life year; the benefit of a program could be defined as the gain in quality life years. There is some agreement that the increase qualtty life years that take place in the future should be discounted (see Mendeloff, 1982, and Stassen and Weinstein, 1978, and below). There is less agreement on the rate of discount rate to be used.

The concept of quality life years has gained some acceptance in theory and practice. While significant advances are being made, existing indices suffer from problems of reliability (repeated measurements tend to give different results), validity (there are doubts about the values given to the health states) and definitional consistency (what constitutes health). Despite these problems, quality adjusted life years have been used in a number of cost-effectiveness studies Klarman (1968) investigated the cost-effectiveness of various therapies for chronic kidney disease, OTA (1979) studied the effectivness of pneumoccal vaccine, and Stassen and Weinstein (1977) to studied the effectivness of the management of hypertension. In each paper the method used to adjust for quality of the life year was made explicit. Thus one could assess the importance of the adjusment.

Since we would argue that the purpose of occupational health and safety programs is not only to avert premature deaths but also to effect the health state of the workers, we would recommend that research in this area be encouraged.

Valuation/Monetization

The number of discounted quality life years gained represents the complete aggregation of all health effects of a program both across people and across effects. To do a complete cost benefit analysis, all effects of the program must be translated into dollars. Monetization is inherently controversial since it attempts to make commensurate sensitive human values and everyday economic behavior. Many people find any attempt at monetization to be absurd, unethical, or imprudent. Here we point out some methods used to estimate monetary values and then examine these more general objections.

The Human Capital Approach. The first systematic approach, and the most widely used one, of putting a dollar value on premature death and on lost work days is the human capital approach (Dublin and Lotka, 1946, Rice 1968, Cooper and Rice, 1976). Regarding a human as if that person were a valuable machine, the method sums the discounted value of earnings in future years. The loss in the present discounted value of earnings due to premature death is then the dollar value of this death. The method can be used to value any health state that is a temporary or permanent deviation from the health states that would be expected in this individual over time. For example, an acute disease episode that caused two days of absence from work would be monetized in terms of the lost earnings. A chronic disease that led to additional days of work absence each year or that necessitated taking a less demanding, lower paying job would be monetized in terms of the lost earnings. This is done by assuming that each individual will follow the health states over time typical of his cohort, including expected acute and chronic illness and lie expectancy (see Policy Analysis, Inc., 1981).

Using the human capital approach to estimate the value of life or other benefits of reduced disability has been subject to strong criticisms. While there are considerable measurement problems associated with human capital approaches, its ethical implications are the most troublesome. Used exclusively, the approach implies that a worker is worth nothing after retirement, that women are worth less than men (since they earn less), that blacks are worth less than whites (since they earn less), and that children are worth little (since it will be many years before they have sizable earnings). Human beings are not machines!

To some extent, these criticisms are misdirected. The human capital approach was not designed to measure the value of life. It was designed, instead, to measure the cost of sickness (Rice and Hodgson, 1982, Hodgson and Meiners, 1982). One real cost of sickness is the indirect costs to society that result from lost output and reduction in productivity due to morbidity and mortality. These losses are real costs. It has been used to measure the value of life because it is the only "measure" that is actually measurable in any consistent and reliable fashion (Policy Analyses, Inc., 1982).

Willingness to Pay Approach

The alternative approach to measuring the value of life and reduction of morbidity is the willingness to pay approach (WTP). WTP, an approach first recommended by Shelling, proposes that the value of life and the value to be assigned to the avoidance of disease and injury be deduced from the amount that people would be willing to pay to reduce the probability of an event such as death from a particular disease. "The idea is that such an expression of the value of health allows policy makers to assess the changes in welfare that would accompany changes in the probablty of occurrence of specific events, such as death from a certain disease, and help to determine social preferences for public policy toward control of disease." (Hodgson and Meiners, 1982).

In practice, the WTP method has been difficult to implement. Researchers have attempted to elicit preferences through surveys that ask people directly about the amount they would be willing to pay to decrease the probability of dying or by examining people's behavior to determine what values they place on their health in everyday activities.

The survey approach, first implemented by Acton (1973) assumes that individuals have explicit preferences that they are willing to reveal when questioned. The survey attempts to pose the question in terms of the relevant situation, e.g., lowering the chance of getting cancer due to workplace exposures from one chance in 100,000 each year to one chance in 1,000,000 each year. These studies find that individuals have an extremely difficult time understanding the meaning of such small probabilities and thinking about how much they would be willing to pay (Slovic, Fishoff and Lichenstein, 1979). Often people give an amount that implies that, if they are taking expected values, the value of their life must be far greater than their earnings or assets. Such high values could be interpreted in one of two ways. Either they are giving an ad hoc response that they would change if they were asked systematically about all life saving, or they are displaying risk aversion and are willing to pay more to lower small chances of premature death than an expected value calculation would predict.

People are frequently faced with a number of decisions involving a tradeoff between safety and money. For example, one can buy a safer, more expensive car, pay to have the safety equipment in the car inspected and serviced, or accept a more dangerous job that has higher pay (such as a high iron worker or steeple jack). The researcher analyses the pay or price differentials to deduce how much people will pay to decrease the probability of death and infers from this a value of life. Since this approach explores the actual tradeoffs that individuals currently make, it presumably is a better description of their preferences than that gained through surveys. However, if individuals are ignorant of the true risks or of the tradeoffs they can choose, the measure will not be a good one. At the same time, poverty or other circumstances might pressure individuals to take high risk jobs they they would not otherwise accept. In addition, the people who accept high risk jobs may be less risk adverse than average.

Table 1

Willingness-to-Pay Estimates of the Value of Life[a]

Method	Value per Statistical Life (thousands of 1977 dollars)[b]
Survey Approach	
Acton (1973)	38
Jones-Lee (1976)	8,440
Landefeld (1979)	1,200
Revealed Preference	
Labor Market	
Dillingham (1979)	277
Thaler and Rosen (1975)	364
Viscusi (1978)	1,650
Smith (1976)	2,045
Olson (1981)	5,935
Consumption Activity	
Dardis (1980)	101[c]
Ghosh, Lees, and Seal (1975)	260
Blomqist (1979)	342
Portney (1981)	355

---

[a] Where a study included a "central" or "most reasonable" estimate, that is shown; where only a range was given, the lowest value is presented.

[b] Values were converted to 1977 dollars using the U.S. Bureau of Labor Statistics Consumer Price Index (CPI).

[c] It is unclear from the Dardis study what year dollars apply, although the estimate presented here appears to be based on an average value for the period 1974-1979.

Using these two approaches, analysts have generated very different estimates of the willingness to pay to lower the chance of premature death and the implied value of a statistical life. The results of the this work have been summarized by Landefeld and Seskin and are presented in Table 1 below. It can be seen that the estimated values of life are so diverse that they provide little guidance to public policy makers.

Adjusted Willingness to Pay. One attempt to marry these two approaches tries to specify what a rational individual should be willing to pay to avoid the financial losses associated with premature death (Landefeld and Seskin, 1982). Income other than labor income is introduced. Adjusted willingness to pay is calculated by formula (1) which specifies the sum from this year through the rest of life (death is assumed to occur in T years) of after tax income Y_t (including both labor and nonlabor income) discounted to the present where r is the rate of discount is a risk aversion factor.

$$(1) \qquad \mathrm{AWTP} = \mathop{}\limits_{t=1}^{T} \frac{Y_t}{(1+r)^t}$$

This approach is an improvement over the strict human capital approach since it includes nonwage income and a risk aversion factor. The last gives sufficient flexibility that any individual could choose a risk aversion factor that made this adjusted human capital measures equal to that individual's willingness to pay measure. The adjusted willingness to pay, however, excludes the fact that family, friends, coworkers and strangers may be willing to contribute to decrease the probability of a given individual death. In addition, some of the normative implications of a AWTP may be difficult to accept. Since the estimated value of life depends on both income and wealth, the implied value of life for someone with low income earning potenial is relatively lower than that under the human capital approach.

None of the three methods for valuing lives is very satisfactory. Whichever method is used to estimate a cost of premature death, it is important to distinguish between the figure used by an individual in making his own choices and a figure that might be used by a regulatory agency. In choosing a job, car, or other safety related behavior, an individual can be expected to tailor the decision to his individual preferences to the extent possible. Unless the individual wishes to take a risk so high that it is essentially suicide, the individual can be left to make his individual choices. In contrast, a regulatory agency must make a decision for a group. By choosing a higher level of safety than is desired by an individual, the agency is forcing the individual to forego income or increase his expenditures. By choosing a lower level of safety than the individual wishes, the agency is forcing him to bear more risk than he would like. Since risk preferences differ, there is no perfect decision.

If the health benefits must be monetized by a regulatory agency, we would argue that decrease in disability days be monetized using the human capital approach. If the disability days are particularly painful, we would recommend that they be inflated to adjust for life quality. We would recommend that premature death be valued using the adjusted willingness to pay approach. However, we believe it would be socially unacceptable for a regulatory agency to require four times as high a safety level in one industry because its workers earn four times as much as those in another industry. Instead, in estimating the cost of premature death the average wage and wealth level of the age cohort should be used. Insofar as the higher paid workers desire a greater level of protection, they can negotiate that directly with their employer. (Other people have made somewhat similar recommendations. See Zeckhauser and Shephard, 1976, and Mendeloff, 1982.)

8. Making Effects Comparable Over Time

The effects of an occupational health and safety programs are often realized over periods of years. The costs of the program tend to be greatest in the initial years, particularly if there is a large capital investment required, while the benefits accord in later years. The question is how to add the benefits and costs so as to value them in the present.

Economic theory has dealt elegantly with consumption and savings over time. The simplest model is of two periods, with the consumer being able to borrow or lend at a fixed rate. The consumer seeks to maximize utility by rearranging consumption over time, subject to the constraint that all debts are paid. This is done by having the ratio of the marginal utility of consumption in the second period relative to the first equal one plus the discount rate (at which he can borrow and lend). Thus, a windfall that produces an additional dollar's worth of consumption in the second period would increase utility by an amount equal to one in the second period or by $1/(1+r)$ in the first period, where r is the discount rate.

This model is generalized to n periods and different rates for borrowing and lending in each period so that there are 2n discount rates. Then a windfall that produces an additional \$1 of consumption in period j is worth $1/(1+r_j)(1+r_{j-1})\ldots(1+r_2)$ where r_j is the relevant discount rate between period j and period j-1. If the consumer is a borrower, it will be the borrowing rate and if the person is a lender, it will be the lending rate.

A large economic literature attempts to specify the relevant discount rate for dealing with financial transactions in future periods. Problems exist in going from the simple model to the real world because of distortion (introduced by taxes), market imperfections and externalities. (A recent survey of this literature is found in Policy Analyses, Inc. According to ABT, "It is now generally agreed that the benefit streams of public projects should be discounted at a social time preference rate, and that the opportunity cost of funds for public sector invetment be reflected in the project's cost through the use of shadow prices placed on displaced resources of the private sector" (p. 5-49). As there are no good estimates of the social rate of investment, they recommend that cost of illness studies, and by inference evaluations of occupational health and safety programs use three social discount rates—2%, 4% and 6% (5-65). These interest rates are lower than the 10% level recommended by the Office of Management and Budget.

These discount rates apply to those benefits and costs that can be monetized. The question is—if one stops at complete monetization of benefits—and uses quality life years gained as the benefit, should those too be discounted? Analysts who have thought about the issue agree they should be although there is little agreement about what the rate should be (Mendlehoff, 1982, Weinstein and Stason 1977, and Keiler and Cretin, 1980).

VII. Reexamination of Recent Occupational Health Regulations

To gain a better understanding of the implications of applying each of the frameworks to occupational health and safety decisions, we present a reexamination of four recent occupational health regulations. These regulations pertaining coke oven emissions, benzene, vinyl chloride, and cotton dust have been the subjects of major controversy. In each case we give a brief description of the health effects and remaining uncertainties. We then describe the regulation that OSHA published along with any subsequent litigation. Finally, we describe the results of applying each of the frameworks to the case.

Not all of the frameworks are applied. The direct risk-risk analysis is irrelevant since exposure to the toxic agent does not help the worker's health. The indirect risk-risk analysis requires more facts and calculations than could be done here. However, it is likely to be approximated by benefit-cost analysis.

We do not attempt to apply a risk-benefit framework, since that would be an approximation for the benefit-cost framework, if properly applied. We also do not consider the legislative veto, since we have no idea whether Congress would find particular stringent regulations to be appealing. Undoubtedly, the vinyl choride standard would have been upheld, since it dealt with a cause celebre. Perhaps the cotton dust or coke oven emissions standards would have been overturned, since they were certain to cost many jobs. Even after the fact it is difficult to estimate how many jobs were lost. However, since there has not been a legislative veto in this area, one cannot predict Congressional actions with any confidence.

The Supreme Court decision in the benzene case requires that OSHA, and presumably other federal regulatory agencies, find there is a significant risk under present conditions before it can consider regulation. This ruling elevates the notion of "significant risk" to make it a necessary step before any of the government regulatory frameworks can be applied. An appendix to this report describe some of the approaches that might be used to define significant risk. In each of the examples below, we try to offer data on whether the risk is a significant one that would pass the Supreme Court hurdle and permit government regulation.

Coke Oven Emissions

Bituminous coal is made into coke to produce a clean, uniform fuel that is widely used in steel making. The coking process heats coal to high temperatures in an oven with too little oxygen to permit combustion. Heating drives off impurities, such as sulfur and hydrocarbons, leaving virtually pure carbon. The resulting gases consist of carbon monoxide, coal tars, sulfur oxides, and other chemicals. Even in modern coke ovens where thse gases are not vented into the atmosphere, workers are exposed to them as they escape through cracks in the doors or piping, as the hot coke is removed from the oven, and as the coke is quenched to cool it.

The chemical stew of gases is highly toxic. The coal tars in particular have been identified as potent carcinogens for more than a century. The composition of the gases changes with the composition of the coal, temperature of the oven, and other factors. Rather than attempt to identify the numerous chemicals making up this mixture, the gases are simply characterized in terms of coal tar pitch volatiles (CTPV) or benzene soluble organics.

In 1969, the Secretary of Labor adopted a CTPV threshold limit value of 0.2 milligrams per cubic meter of air. This standard was adopted by the newly created Occupational Safety and Health Administration in 1970 along with a host of other pre-existing standards. In 1971 first the American Iron and Steel Institute and then the United Steelworkers of America filed petitions with OSHA asking for, respectively, a modification that would relax the standard and one that would tighten it. When the results of an well done epidemiological study became available, OSHA acted to lower the standard to 0.15 milligrams of CTPV per cubic meter of air. The final standard was published on October 22, 1976 and became effective on January 20, 1977. The steel industry petitioned the Secretary of Labor to stay the standard and then went to court to have the standard reviewed. The Third Circuit Court of Appeals upheld all the relevant parts of the standard. The industry than appealed to the Supreme Court, which agreed to hear the case. Later, however, the industry withdrew their appeal before the case could be argued.

Since the epidemiological study showed an increase in lung and other cancers among coke oven workers, OSHA selected a standard that was based on technological feasibility for control. OSHA did make some estimates of the number of cancers that would be avoided by lowering the standard, but the estimates . of control were rudimentary, it did little to examine the economic feasibility of the standards, and certainly did not attempt benefit-cost or cost-effectiveness analyses.

Based on a dose-response relationship estimated by a consultant on leave from the National Cancer Institute, OSHA estimated that the more stringent standard would prevent 240 excess lung cancers each year; a much more modest estimate was prepared by the Council on Wage and Price Stability, which estimated that between 8 and 36 deaths per year would be prevented. One might put together these two estimates to get a range of 40 to 150 lung cancers averted each year due to the standard.

OSHA estimated that the cost of implementing its standard would be $__ per year. COWPS estimated the cost would be $__ per year. We know of no study that documents what has actually been spent on implementing the standard and how successful efforts have been.

While some data are missing, it is possible, at least roughly, to apply each of the frameworks to investigate what would have been the result if each had been used for deciding the health standard for coke oven gases. The first framework is a combination of market regulation and court suits. Certainly, there is evidence of worker concern as expressed in the USW petition to OSHA for a more stringent standard. However, this concern does not appear to have been strongly expressed during collective bargaining. If no state or federal regulation existed, worker exposure to coke oven gases would eventually have become a matter for collective bargaining. While this process might have been lengthy, it might have led to more rapid and complete implementation of the agreement. Undoubtedly, a strong force to get industry to agree could have been worker suits were the prohibition of these suits by workers' compensation lifted. With the evidence of the epidemiological study, any coke oven worker who contracted cancer would have a good chance of receiving substantial compensation. Such awards, the accompanying publicity, and substantial costs of litigation would put pressure on companies to reduce worker exposure to these gases. Thus, while collective bargaining would probably not have arrived at a stringent standard, law suits might have. In particular, if each lung cancer victim were awarded $1,000,000, this would make it attractive for the companies to reduce exposures substantially. The increases costs of insurance policy to protect compares against these costs would help to push for control.

Better worker information would have led to more militant behavior, particularly at collective bargaining. However, since coke oven workers are a tiny proportion of steelworkers, it would have been difficult to get general agreement to make coke oven emissions a central issue. Since these workers are already paid a substantial premium over what they could earn in alternative employment, it is doubtful they could bargain for a risk premium.

Voluntary industry standards were not stringent or adhered to and this framework seems to have been irrelevant to decisions regarding coke oven gases.

Presumably, all government regulatory frameworks are subject to a substantial risk finding. In this case, the epidemiological study makes the substantial nature of the risk evident. Thus, this hurdle is cleared.

The first regulatory framework is no-risk. Since there are potent carcinogens in the gases, this framework would have called for banning coke ovens, or at least requiring a change in process that would reduce worker exposure to unmeasurably small amounts. Such a standard would probably have led to shutting down all US coke ovens and importing coke.

Compared to the current standard of 0.15 milligrams, this standard would have led to many lost jobs in the steel industry at only a miniscule gain in terms of reduced cancers.

Technology based standards (technological feasibility) was the framework actually used by OSHA, since costs within the relevant range were deemed to be economically feasible. Industry disputed whether the technology existed for achieving the standard for many of the older coke ovens. This decision framework is meaningless since more stringent control could be achieved at greater cost. For example, the ovens could be completely enclosed within hoods that collected the escaping gases, and this complete collection could be continued during unloading the ovens and quenching. Such a system would be much more expensive and possibly not economically feasible, but surely would be technologically feasible.

The steel industry also contended that the OSHA standard was not economically feasible. The current state of the steel industry has made this assertion true. However, these additional costs would have only a minor effect on the cost of steel. It would be an unwelcome addition to already noncompetitive costs, but surely would not be large enough to be decisive.

A cost-effectiveness test could be applied either by comparison with other opportunities for enchancing the health and safety of steel workers or other opportunities for all workers. It would appear that improved personal protective devices would decrease exposure at lower costs than engineering controls, although with worker discomfort. We know of no attempt to evaluate the cost-effectiveness of more general health and safety measures in the steel industry. Certainly, there are many opportunities open to OSHA to save the lives of workers at lower cost than is implied by the current coke oven standard.

The regulatory budget would give OSHA some annual limit on the costs its regulations could impose on employers. The administrator of OSHA would then be faced with selecting from among the possible regulations a set that improves worker health and safety most for these costs. Insofar as loggers and construction workers could be saved more cheaply than coke oven workers, this regulation would be pushed aside.

In view of the latency period between first exposure and onset of cancer, the cancers would occur a decade or more in the future, the choice of a discount rate would be crucial. At the OMB rate of 10% per year, the present discounted value of reducing the incidence of cancers would be extremely small, implying that stringent abatement was not worthwhile. Even at a much smaller discount rate, a latency period of one-to-three decades would discount the value of reducing the incidence of cancer significantly.

Since the costs are also subject to major uncertainty, a range of estimated costs would have to be used. The result of using a range of estimated benefits, several discount rates, and a range of estimated costs would be to produce a number of estimates of the net benefits of abatement. There is sufficient uncertainty that we have not attempted to state such estimates. However, one conclusion is evident. Since companies would attempt to comply with the standard by improving the fit of coke oven doors and to check and maintain them more often, it becomes increasingly expensive to achieve more stringent standards. In going from a standard of 0.155 milligrams to 0.150 milligrams, the cost per cancer averted is subtantially greater than the estimates presented above. A marginal calculation would keep the standard from being set at so stringent a level. Thus, a benefit-cost analysis almost certainly would not lead to a standard as stringent as that set by OSHA.

Benzene

For extended exposure above 100 ppm, benzene causes various diseases of the blood forming organs, such as pancytopenia and aplastic anemia, and is believed to cause leukemia (Bartman). Effects at lower dose levels are more uncertain. Benzene is a clear, colorless liquid used extensively in the petrochemical and refining industries. About 11 billion pounds were produced domestically in 1975 to be used in the production of organic chemicals, some detergents, and pesticides. In 1971 OSHA adopted a prior voluntary standard of 10 ppm set by the American National Standards Institute. Although petitioned by the United Rubber, Cork, Linoleum, and Plastic Workers of America to set a more stringent standard, OSHA refused to do so. By mid 1976, NIOSH issued a report finding benzene to be a leukemogen and recommending that the standard be set at 1 ppm, which they believed to be the lowest technologically feasible standard. On May 3, 1977, OSHA issued a 1 ppm emergency temporary standard; this was stayed and never went into effect. On May 27, 1977, OSHA published a proposed permanent standard with the 1 ppm ceiling. This was also subject to court challenge. It was set aside by the Fifth Circuit Court of Appeals on the grounds that the agency hadn't conducted a benefit-cost analysis. The Supreme Court affirmed the appeals court decision on July 2, 1980, but on different grounds. While declining to rule on whether a benefit-cost test should be done, the plurality agreed that OSHA could not regulate unless it found that current exposure present a "significant" risk. Apparently, OSHA had not only failed to conclude that a 10 ppm exposure to benzene presented a significant risk, but also the justices seemed implicitly to doubt that the existing standard did indeed present a significant risk. Unfortunately, no opinion received a majority of votes, and the plurality opinion was a weak one.

OSHA had argued in setting the 1 ppm standard and in its appellate briefs that quantitative risk assessment was impossible or at least uninformative given the current data. However, some risk assessments, including a rather comprehensive one by EPA, had been done. These assessments make it clear that revising the standard from 10 to 1 ppm would have a small, perhaps negligible, effect on the number of expected leukemias among workers exposed to benzene. Although there is uncertainty about the number of workers exposed at various levels, as well as about the dose-response relationship, the two risk assessment studies presented at the hearing seem to agree that changing the standard from 10 to 1 ppm would lower leukemia incidence by less than one case per year. OSHA estimated that the capital cost of complying with the more stringent standard would be $267 million, while the first year operating cost could be $124 million and annualized costs would run $74 million.

The focus on leukemia distracted OSHA from examining other deleterious effects of benzene. The included other chronic effects, such as chromosome damage or damage to the blood forming organs as well as damage to fetuses. Certainly, these effects should be counted in the estimated benefit of abating exposure to benzene. In addition, the OSHA analysis does not examine the effects on the general population, which is regulated by EPA, or what effect abating occupational exposure might have on curtailing general population exposure.

Continuing to focus on leukemia, it is possible to apply the various frameworks to OSHA's benzene standard. As noted by their petition to OSHA, the Rubber Workers were concerned about the health effects of benzene. Like the steelworkers, they believed it to be advantageous to reserve collective bargaining for wage and fringe benefit issues, leaving health and safety issues for federal regulation. Without federal regulation, the concern displayed by the Rubber Workers makes it likely that benzene exposure would have become a collective bargaining issue. While it seems doubtful that the union would have insisted on a 1 ppm standard, since they have not done so in subsequent collective bargaining, it is impossible to know the outcome of this bargaining.[6]

Were employees allowed to sue their employers because of leukemias, aplastic anemias, and other diseases of the blood forming organs, the suits would certainly pressure industry to attain more stringent standards. Were workers able to win substantial awards, industry would be motivated to lower benzene exposure rates. However, suits might be difficult to win because of the uncertainty about the effects of benzene. Also, important is the low incidence of these conditions among workers. However, the costs could be substantial enough to motivate standards more stringent than 10 ppm.

OSHA adopted its initial 10 ppm standard from a voluntary industry standard. While this standard was voluntary, there appeared to be general compliance with and some industry concern about whether it was low enough. Had the standard setting been left to the voluntary process, it might well have been made more stringent as new epidemiological evidence accumulated as well as effects other than leukemia became of greater concern. Thus, it is not obvious than mandatory OSHA standards resulted in workers being exposed to lower doses of benzene than they would have been without OSHA.

The Supreme Court held that OSHA had not demonstrated that worker exposure to 10 ppm of benzene presented a "significant" risk. This finding would evidently preclude regulation under any of the govermmental frameworks. However, we can examine what standards would be arrived at by the various frameworks, assuming significant risk was not a necessary condition for regulation.

The no-risk framework would have noted the leukemogenicity of benzene and banned the chemical or reduced exposure to as low as feasible. Banning is impossible and unthinkable in a modern industrial society, but steps could be taken to ban the use of benzene in products or processes where there was a substitute. If so, the costs probably would be so large as to be staggering. This is not a helpful framework.

Technological feasibility was the criterion used by OSHA, since it assumed that costs within the relevant range were feasible for the industry. However, it is evident that sill more stringent standards are technologically feasible, at least for most of the workers exposed. For example, benzene could be banned whenever there is a substitute and vented better when substitution is not possible. If implemented rigorously, this framework would produce a standard that was not economically feasible.

Since the industry regulated the is petrochemical industry, economic viability is not an issue at 1 ppm. The industry makes large profits and the expense of benzene control is small, relative to gross revenues or profits. If the only criterion were technological feasibility, with an economic feasibility constraint, then a more standard stringent than 1 ppm would have been set. Thus, OSHA had too little courage (or too much sense) to adhere strictly to the Congressionally mandated decision framework.

A cost-effectiveness framework might look either at other standards to protect rubber workers or other occupational standards generally. We know of no study of the cost-effectiveness of standards for rubber workers. However, since the implicit cost per life saved is on the order of $100,000,000, there have to be more cost-effective standards than benzene (Nichols). Certainly, if one looks at all possible standards for workers, there are many more cost-effective standards than than for benzene.

The same conclusion would be reached if the regulatory budget were in use. The administrator of OSHA would have more important chemicals to focus on than lowering the benzene standard to 1 ppm. The OSHA focus on benzene arose from political rather than cost-effectiveness considerations (Bartman).

A benefit-cost analysis would show OSHA's benzene standard to be far too stringent. Although there is uncertainty about the proper dollar value to be attached to averting a premature death, no one believes the estimate is remotely close to $100,000,000.

Benzene appears to be a case where federal regulation has made a muddle of the pre-existing situation. Even without the stimulus of collective bargaining and damage suits, industry had adopted and generally adhered to a stringent 10 ppm standard. If this mechanism had been allowed to continue, the voluntary standard might well be more stringent than that currently enforced by OSHA (10 ppm). More importantly, if workers were put on notice that collective bargaining was the proper mechanism to settle health and safety issues, the standard would probably be a better one, with more agreement by companies and workers.

Vinyl Chloride

Vinyl Chloride monomer is the chemical base of the second most commonly used plastic. In 1971 OSHA adopted a voluntary industry standard of 500 ppm, designed to prevent severe acute effects. However, exposure at that level caused enlargement and fibrosis of the liver and spleen, as well as other adverse health conditions. To eliminate these acute effects, the group that developed the earlier consensus standard, the American Conference of Government and Industrial Hygienists, recommended to OSHA in 1972 that the standard be lowered to 200 ppm; OSHA took no action. No careful epidemiological studies had analyzed the effect of VCM on humans and animal studies were not given great weight.

In 1974 Goodrich reported that three workers at its Louisville plant had recently died of angiosarcoma of the liver; a fourth death occured five years earlier. These cancers are extremely rare and the cluster of cases suggested industrial exposure to a carcinogen. Other companies also reported angiosarcomas among their workers exposed to VCM and long term bioassays confirmed the link of VCM to angiosarcoma. Within four months, OSHA issued an Emergency Temporary Standard of 50 ppm, based on what it believed to be technologically feasible. However, the bioassays found first that 50 ppm induced angiosarcoma in rodents, then that 25 ppm did; finally, they found that 1 ppm induced mammary tumors. Six months after the temporary standard, OSHA published a permanent standard of 1 ppm.

Industry sued OSHA claiming that the standard was not technologically feasible. OSHA's own consultant supported this claim and estimated that the cost of achieving a more relaxed standard would be $1,900 million (Connerton and MacCarthy). The Second Circuit Court of Appeals rejected the claim, noting that not all possible abatement technologies had been evaluated and that technological advances were likely when industry began to work on implementing the standard.* In fact industry did find abatement technology to enable it to comply with the standard. Furthermore, the costs appear to be substantially less than those estimated by OSHA's consultant for implementing a less stringent standard.

OSHA did not attempt to estimate a dose-response relationship. Instead, the results of the animal bioassays showing angiosarcoma at 25 ppm and mammary tumors at 1 ppm drove OSHA to a standard that they hoped would be technologically feasible. Further evidence of angiosarcoma among workers accumulated and at least 68 cases are known to have occurred among VCM workers (during the period of the 500 ppm standard) (Doniger).

This case developed so quickly that there was no time for industry voluntary standards, collective bargaining, or other private action. OSHA was in charge and there was little or no reason to attempt private action that would appear to be second guessing OSHA. If OSHA had not been in existence, the industry voluntary standard would likely have been lowered to 200 ppm in 1972. An announcement of the four deaths and other evidence would have led to further consideration of lowering the voluntary standard. In view of the high level of worker concern, the standard would almost certainly have become a subject for collective bargaining, assuming no other institution existed to lower the risk. It is likely that OSHA did a better job of coordinating data and action than could any group under a voluntary standard. However, industry could not have ignored the deaths.

Even if allowed to sue, it is doubtful that court awards would have prompted a standard as stringent as 1 ppm. For example, the 68 reported cases of angiosarcoma were spread over at least half a dozen years and occurred at high exposures. Exposure levels of 10 or even 50 ppm would be expected to produce only a few angiosarcomas each year. Even punitive awards of several million dollars per death would have provided an incenive far smaller than the anticipated control cost of $1900 million or even of the $1127 experienced. It seems likely that court awards would prompt industry to comply with standards at least in the 10 to 50 ppm range.

Since more than 68 cases of angiosarcoma were reported, there is clearly a significant risk among workers exposed to VCM. Having cleared this hurdle, government regulation can be considered.

The no-risk standard would have called for the banning of VCH, at least where substitutes exist. It would be possible to run the economy without vinyl plastics; however, this would mean a significant loss of choice and an enormous cost to consumers. Presumably, substitute plastics are not used because they are less suitable or more expensive. This framework does not produce an attractive solution.

The OSHA standard was not technologically feasible when published. If OSHA were bound by demonstrated technological feasibility, they would have had to issue a standard of perhaps 5 ppm. Instead, they conjectured control technology to achieve 1 ppm was "looming on today's horizon." In cases such as this one, there is no good solution. OSHA was lucky in this case; if 1 ppm had turned out to be infeasible, they would have had to decide whether to ban VCM or tolerate a less stringent standard and a measurable number of angiosarcomas.

Economic feasibility was not an issue even at control costs of about $1 billion, since the plastics industry is profitable. Still more stringent standards could violate economic feasibility.

A cost-effectiveness test would probably have led OSHA to stop short of a 1 ppm standard. Costs would be much lower, but most of the angiosarcomas would still be prevented at a standard like 5 ppm. Rather than lower the standard further, cost effectiveness wuould have directed OSHA's attention to other chemicals. Similarly, the regulatory budget would have pushed for a less stringent standard.

A benefit-cost analysis would show a negative, net benefit, for a 1 ppm standard, using any reasonable discount rate and value of premature death.* Thus, a less stringent standard would have been called for. According to the consultant, it would be significantly less expensive to meet a standard of 5 or even 10 ppm would have. At that standard, most of the angiosarcomas would be eliminated. Benefit-cost analysis a standard would be set at using perhaps 5 to 10 ppm. However, some angiosarcomas would still occur at the new standard.

This case emphasizes the difference between statically optimal and dynamically optimal solutions. The uniqueness and fatal nature of the disease prompted a search for new process and abatement technologies that would lower exposure to the point where no angiosarcomas would be expected to occur. A new technology was found that both achieved the objective and did so at a fraction of the cost estimated for a much less stringent standard. If there had been less regulatory pressure, it is possible that a much less satisfactory solution would have been found.

Cotton Dust

Byssinosis, or "brown lung," is a chronic, incapacitating lung disease that has been linked to dust from cotton or flax for more than 200 years. The pathology is that of a nonspecific chronic bronchitis or emphysema. Although the disease occurs among workes exposed to high concentrations of cotton dust, the precise cause is unknown. Byssinosis is most likely to occur to exposed workers who also smoke cigarettes (National Academy of Sciences).

In its most severe form, byssinosis, which has symptoms skin to those of chronic bronchitis or emphysema, can totally disable an individual. Approximately 250,000 workers are exposed to cotton dust and 35,000 workers and retirees are estimated to be disabled by byssinosis (Merchant).

In 1971 OHSA adopted a previous Department of Labor regulation setting the standard for expsoure to cotton dust at 1,000 micrograms per cubic meter. In 1974 the American Conference of Government and Industrial Hygienists changed the measurement technique and reduced the threshold limit value to 200 micrograms per cubic meter, which is roughly equivalent to the British Occupational Hygiene Society recommended standard. In June 1978, after much debate, OSHA published a revised standard for cotton dust that set different permissible levels for various types of activities: 200 micrograms for yarn manufacturing, 750 micrograms for slashing and weaving operations, and 500 micrograms for all other processes. These standards were chosen to equalize risk in the various settings.

The standard was immediately challenged by the industry whichclaimed that it was too costly and that OSHA should have applied a benefit-cost analysis in choosing the standard. The standard was affirmed in all important respects by both the appeals court and the Supreme Court. The latter held explicitly that Congress wrote into the legislation the goal for protecting workers. In particular, Congress required that OSHA protect workers to the extent feasible and made no mention of a benefit-cost test. OSHA has interpreted feasibility to mean both technological feasibility (that the standard is technologically achievable) and economic feasibility (although individual firms may not survive, the industry will not be bankrupt). Thus, the language of the statute and its interpretation by OSHA call for more stringent standards than would result from a benefit-cost test.

In this decision, together with the earlier benzene decision, the Supreme Court appears to be requiring OSHA first to determine if a significant risk exists at the current standard. If so, then apparently OSHA must protect the worker, subject to the two tests of technological and economic feasibility, at least until the risk ceases to be significant. Unfortunately, the Supreme Court gave no guidance as to what constitutes a significant risk or what is the relevant test for technological and economic feasibility. Prior court decisions indicate that OSHA can satisfy the technological feasibility test by simply claiming that technological change will result in new technology that can do the job and will do so at a low cost?

The controversy over the draft cotton dust standard revolved around three issues: (1) economic feasibility or how much of an increase in cost the industry could absorb; (2) the extent to which cotton dust differs in the various processes so that higher concentrations in one operation were equivalent in health terms to lower concentrations in another, and (3) the extent to which personal protective devices or other nonengineering controls could be substituted for the more costly engineering controls.

In the post-World War II period, there has been increasing competition from foreign textiles. The resulting plant closings and lost textile jobs have been mitigated by formal and informal quotas on the importation of foreign textiles. Although OSHA argued that its standard was economically feasible, there remain questions about the number of plants that would be closed and the number of lost jobs if the standard were rigorously enforced.

OSHA appeared to conclude that the industry should focus its resources on reducing dust in the yarn manufacturing process, with few resources going to reducing dust exposure in the weaving process, because of different health risks in the two operations. Morrall found that the cost of reducing exposure in the various processes was vastly different. He argued that these differences in the cost of compliance should have been built into the regulation so as to make it more cost-effective. OSHA went part of the way in accepting this recommendation.

OSHA estimates that the cost of engineering controls to meet the OSHA standard would come to $42,757 per case of byssinosis avoided. Since the byssinosis occurs sometime in the future, the benefits must be discounted to make them commensurate to the costs which are incurred at present. According to Morrall's calculations, the cost of prevention by engineering controls is perhaps seven times greater than the discounted benefits. Morrall estimates that the cost per case of byssinosis prevented to range from $30,000 to $300,000 with the best estimate about $135,000.

Reducing occupational exposure to cotton dust can be examined via the frameworks. The marketplace did not do much to reduce the incidence of brown lung disease. In the post-World War II era, there has been competition from foreign textiles. The result is successive plant closings and more unemployed cotton workers. In this economic climate, health issues seemed to be loss important to workers than preserving employment. The industry is generally not unionized, and so there is no collective bargaining. Furthermore, wages are low and presumably workers are unwilling to sacrifice wages for a healthier workplace. In a moribund industry with low or negative profits, low wages, and no unions, one would not expect voluntary standards to play a role.

It is possible that courts might make significant awards to brown lung victims if workers' compensation permitted a worker to sue his employer. However, bysinossis is generally not compensated under workers' compensation. Since this failure can be taken as one indication of local attitudes, if the cases were tried locally, it is doubtful that local juries would make major awards. All would be aware of the precarious financial circumstances of the mills and would be reluctant to impose an award that could bankrupt the mill. Thus, nongovernmental standards are unlikely to work well.

Given the tens of thousands of cases of brown lung disease, there is no difficulty in meeting the significant risk test. Thus, it is safe to go on to each government regulatory framework.

The no-risk framework would ban cotton processing or mandate stringent technological standards. The result would almost certainly be that most of the cotton textile industry would disappear from the USA.

If technological feasibility is the criterion, then highly stringent standards could be set. Much of the work currently performed by workers could be mechanized and humans removed from the setting. Weaving machines could be almost completely enclosed, with the air and resulting cotton dust sucked up for dust removal. It would be technologically feasible to reduce worker exposure to the point where virtually all brown lung disease was prevented.

However, even moderately stringent standards would run afoul of economic feasibility in older plants. This industry has been slowly dying in the USA, kept alive by tariffs and quotas. The plants and equipment are old. Foreign labor is sufficiently cheap that the industry does not appear to be economically viable in the USA. Thus, the policy issue becomes how long does one seek to preserve these jobs, knowing that workers will be breathing levels of cotton dust that will cause increased rates of brown lung disease? The answers are not simple either from an economic or political standpoint.

Cost-effectiveness would lead to a different standard, according to Morrall. More generally, partial or total disability is being prevented (at the current OSHA standard) at costs on the order of $135,00 per case. Given this relatively low cost and the number of workers involved, it would seem to be cost effective to have a standard at least as stringent as that mandated by OSHA. Similarly, the regulatory budget would dictate that OSHA should give high priority to this standard, relative to other occupational hazards.

A benefit-cost test is difficult here since the answer will depend on the precise discount rate chosen and the value placed on preventing an additional case of brown lung. There is a lag of a decade or more between exposure and the onset of severe symptoms. Thus a high discount rate would lower the estimated present benefits and mandate a relaxed standard. Similarly, if a low value is placed on disability due to brown lung, a stringent standard would not be justified. This is precisely the type of case where reasonable analysts can choose values within the range accepted by the economics profession and wind up with opposite conclusions about the desirability of a stringent standard.

VIII. Conclusions

By the late 1960s, there was widespread agreement that many workplaces were too dangerous and that the incidence of occupational disease was too high. Congress reacted by creating an agency to deal with occupational accidents and disease and giving it a broad mandate. The problems and accomplishments of OSHA are best viewed within the context of federal health and safety regulation more generally.

Relative to initial expectations or the extent of the problem, OSHA's accomplishments are disappointing. They could be criticized on the three major criteria of economic efficiency, equity, and administrative simplicity. It is naive to call for improvements in all three criteria simultaneously. What is needed is a change in emphases—along with changes in the way OSHA tries to accomplish its goals.

OSHA, in particular, and federal health and safety regulation more generally, are in more danger of being paralyzed by their own red tape, their cumbersome procedures and somewhat arbitrary decisions than of failing to appear responsive to worker demands for protection. The major explanation for the slow progress lies with vaguely articulated goals, a focus on equity issues, and a near complete rejection of efficiency concerns. One result has been nearly endless discussions of the equity claims of workers, stockholders, and consumers. If an industry cannot afford to protect its workers adequately, should they be safe and unemployed or employed at risk? Alternatively, the industry could be subsidized. If economic feasibility precludes bankrupting an industry, there will be great variations in the level of federally imposed standards depending on what industry one happens to work in.

Economic efficiency offers some guidance about the importance of economic viability; the present lack of agreement as to what constitutes equity means that placing the emphasis here will produce only conundrums.

Our review makes clear the important role that formal evaluation should play in occupational safety and health decisions. It sharpens the questions, clarifies the implications of policies, and generally manages to attain solutions at lower cost. We do not believe that any of the regulatory decision frameworks, from technical feasibility to benefit-cost analysis, can be used as automatic guides to policy; there is always so much uncertainty and the need for so much judgment that any mechanical rule for making decisions would prove unsatisfactory.

Indeed, we believe that evaluation ought to play a more important role in health and safety decisions. The quality of the scientific information can be improved, along with the quality of the economic data base. Uninformed or semi-informed judgments by policy makers can be improved by putting more resources into the scientific data base and improving the quality of the evaluation. There is an important positive feedback here since giving the scientific information greater weight in the decision process will lead to the generation of better data that will be better tailored to the decision needs. This better data base then leads to greater reliance on the hard data and evaluation. Most important, this feedback leads to decisions that are more firmly grounded in facts and analysis and are more economically efficient. This process would give the appearance as well as the reality of making the decisions more scientifically based, therefore less arbitrary and capricious, and thus less likely to be successfully challenged in the legal or political areas.

Most importantly, using one of the more elaborate frameworks, such as benefit-cost analysis or cost-effectiveness to organize the decision making effort would lead to better data being collected and better analysis of the data and of alternative decisions. These frameworks have a bias toward greater economic efficiency. First they seek to achieve an objective at lowest cost. Second they attempt quantification of effects. If no other objective is stated explicitly, the default option is to maximize economic efficiency, subject to various policy constraints. Thus, they force policy makers to introduce explicit constraints. Furthermore, the analytic process gives as a natural outcome a measure of the cost of various policy constraints so that decision makers get some feedback on the real cost of these constraints; in some cases, the costs prove to be great enough to lead to modification of the constraint.

The case studies of coke oven emissions, benzene, vinyl chloride, and cotton dust reinforce those conclusions. They show that more attention to the science, more careful analysis, and the use of one of the more elaborate decision frameworks are possible and likely to lead to move desirable solutions. They also demonstrate that nonregulatory alternatives, particularly when workers know the nature of the hazards they face, can produce attractive outcomes.

In short, using one of the more elaborate frameworks leads to a different approach to formulating regulations. Although that approach is sufficiently flexible to be used to accomplish almost any end, it naturally emphasizes the scientific foundation and economic efficiency.

In a regulatory process that is drowning in due process, delays, arbitrary regulations, and excessive attention to special groups, a large dose of better scientific understanding and greater economic efficiency seem precisely the proper prescription.

Appendix: Significant Risk

In *benzene*, the court seems to be posing a narrow question when it notes there must be a "significant risk" before an agency can take action.[8] The court seems to be asking the agency to demonstrate or at least "find" that some reasonably substantial *group of people* face a *nontrivial hazard* with a *nonnegligible probability of occurrence*. The damage that results from some event is the product of (1) the "population at risk," (2) the "hazard" that they are a risk for, and (3) the probability that the hazard will occur to this group. In order for the resulting damage to be significant or nontrivial, all three elements must be nonzero and one or more must be large.

The simplest, and perhaps least helpful, approach is to define significant risk as a nontrivial outcome. Thus, death is a nontrivial outcome and presumably one death would constitute a significant risk. Similarly, to the person affected, a chronic disease, severe acute disease, or disability constitutes a significant risk. We doubt this is what the court had in mind for two reasons. The first is the language: even in common, ambiguous usage, significant risk means something different from significant outcome. It refers to the probability of a nontrivial hazard, presumably to a nontrivial group. Confirming this interpretation is the impossibility of preventing all untoward outcomes in an industrial society. The dismissal of "zero risk" is clear, even by the courts. Accidents happen, and we make no real attempt to zero them out. We travel by air knowing there will be disasters; we know that more than 50,000 people will be killed in U.S. highway accidents in 1983, yet we do not shut down the highway system.

Significant risk focuses on the probability of the event, but depends as well on the population at risk and nature of the hazard. Even a small hazard can give rise to a significant risk. Suppose that everyone in Los Angeles experiences eye irritation due to the smog. Although the hazard is small, the size of the population at risk and high probability make the risk significant. Presumably, there is a hazard so small that even if all residents of Los Angeles experienced it with probability one, the risk would not be significant. For example, there is evidence that people adapt to ozone, displaying less of a physiological reaction to a high concentration than people living in clean air. This weakening of a physiological response is presumably bad, but not so significant as to be worth EPA attention. Thus, there is a tradeoff between the nature of the hazard and the size of the population at risk and probability of occurrence.

Another issue is what constitutes a significant hazard. This question is almost entirely subjective and will change over time. Cancer is perhaps the current ultimate hazard; at other times, one can imagine sterility or deformed babies being more important.

Schelling points out the difference between statistical individuals and known ones. We feel differently about some statistical person dying in a highway accident whose name we never learn than we do about a particular coke oven worker who will get lung cancer unless we take action. Occupational disease is different from disease in the general population in two important respects. The first is that the population at risk is small and known. The second is that often the probabilities are so high that we cannot hide behind the "it won't happen to me" rationalization. For example, people working on the topside of a coke oven for 15 or more years had about seven times the probability of contracting lung cancer as steel workers in general. Thus, topside coke oven workers, particularly those with lung cancer, become individuals rather than statistics. When they speak out, we will give them our attention, and we are appalled at the risks.

The central issue is whether probability gets defined absolutely or as a percentage of the "natural" or "background" rate. For example, the angiosarcomas from vinyl chloride were a trivial increase in the cancer rate for these workers, but an almost infinite increase in the angiosarcoma rate. Because this was an extremely rare disease, it was spotted quickly. This is basically the same situation as Pott's discovery of the cause of cancer of the scrotum among chimney sweeps. Given the nature of their job, the decrease in life expectancy due to scrotal cancer among this group must have been negligible. However, the condition was extremely rare, making discovery possible, and leading to intervention. In contrast, discovery of an increase in the incidence in lung cancer is difficult since even a substantial increase in lung cancer deaths would appear to be only a minor deviation from a normal high rate.

Thus, one approach to significant risk is to define it as an observable or statistically significant increase in the background rate. In particular, epidemiology is essentially incapable of spotting less than a doubling of any disease specific death rate; this would say that anything less than a doubling was "negligible." For small groups, the increase would have to be even larger. According to this approach, unless we observed or expected to observe a significant increase in some disease or condition, we would call the risk insigificant. This approach would lead to much higher risks than an approach based on calculated increases in risk.

If the definition is separated from what could be observed in the world, it could be generalized to encompass calculated increases. Would a 50 percent increase in the risk of lung cancer be significant? 10 percent? 1 percent? The percentage increase probably would be tied to the size of the population at risk and the severity of the hazard.

The Nuclear Regulatory Commission has adopted a goal for the general population of not increasing the chance of accidental death or of cancer by more than 0.1%. At the same time, NRC has set radiation exposure standards for workers that would allow 2% to contract cancer, a 10% increase in the cancer rate. Other regulatory agencies have not adopted consistent definitions of risk goals (Lave).

To summarize, a significant risk must be defined with respect to the magnitude of the hazard, the probability of occurrence, and the population at risk. Only if the product of these three factors is significant will the risk be significant. However, there remains a good deal of ambiguity concerning what numbers would constitute a significant risk enabling (or requiring) that OSHA develop a regulation.

Footnotes

1.1 Two programs which generate the same number of additional life years may do so by avoiding different numbers of premature death.

2.1 There is every reason to predict that collective bargaining would arrive at different health and safety levels for each industry, depending on wage rates and industry profitabilty. We suspect that these differences in work conditions would not be considered any more inequitable than differences in wages, as long as there was an acceptable floor on health and safety.

The courts earlier concluded that OSHA need not prove that control technology was currently available to acheive a standard, only that a technologically feasible technology was "looming on the horizon" (American Iron and Steel Institute, p. 838).

The benefits of a 1 ppm standard would consist at saving a few workers each year compared to a 5 or 10 ppm standard. Cost of premature death of about $300,000 would lead to an annual benefit of less than $1 million. Since the costs were greater than $100 million, costs exceed benefits.

However, the relevant language from the OSHA Act is "no employee shall suffer material impairment of health or functional capacity." Strictly interpeted, this language would indicate that any lessening of a health or functional capacity for a single worker would constitute a signficant risk. Clearly, the Supreme Court seemed to be rejecting such a simple interpretation.

IX. References Cited

Acton, J. P., Evaluating Public Programs to Save Lives: The Case of Heart Attacks, Santa Monica, CA: Rand Corporation, R-950-RC, January 1973.

American Iron and Steel Inst. vs. OSHA, 577 F. 2d 825, 838 (6 OSHA 1451, 1461) (3d Cir. 1978, Cert dismissed, 448 U.S. 917 (1980).

Arrow, Kenneth J., "Limited Knowledge and Economic Analysis," American Economic Review, 64, March, 1974.

________________ and F. H. Hahn, General Competitive Analysis, San Francisco: Holden-Day, 1971.

Arrow, Kenneth J. and Mordecai Kurz, Public Investment, the Rate of Return, and Optimal Fiscal Policy, Baltimore, Johns Hopkins University Press, 1970.

Ashford, Nicholas A, Crisis in the Workplace: Occupational Disease and Injury, Cambridge, MIT Press, 1976.

Baram, Michael S., Affirmative to Regulation, Lexington: Lexington Books, 1982.

Bartman, Thomas R., "Regulating Benzene," in Lave, 1983.

Bergner, M., Bobb, H. R., Kressel, S., "The Sickness Impact Profile: Conceptual Formulation and Metholdogy for the Developmetn of a Health Status Measure," International Journal of Health Services 6(3), 393.

Blomquist, G., Value Life of Saving: Implications of Consumption Activity, J. Political Economy, 1979.

Briggs, Dwight D. and Lester B. Lave, "Regulating Coke Oven Emissions," in Lave, 1983.

Connerton, Marguerite and Mark MacCarthy, "Cost-Benefit Analysis and Regulation: Expressway to Reform or Blind Alley?" National Policy Papers, #4, October, 1982.

Cooper, B. J. and D. P. Rice, "The Economic Case of Illinois Revisited," Social Security Bulletin, 39, 21, 1976.

Crandall, Robert W. and Lester B. Lave (eds.), The Scientific Basis of Health and Safety Regulation, Washington, DC, Brookings Institution, 1981.

Cullingford and Niehans

Crump, K. S. et al., "Fundamental Carcinogenic Processes and Their Implications for Low Dose Risk Assessment," Cancer Research, 36, September 1976.

Dardis, R., The Value of Life: New Evidence from the Marektplace. Am. Econ. Rev. 1980, 50:1077.

DeMuth, Christopher C., "Constraining Regulatory Costs, Part 1: The White House Review Programs, Regulation, 4, January-February 1980.

_______________, "Constraining Regulatory Costs, Part 2: The Regulatory Budget," Regulation, 4, March-April 1980.

Denison, Edward F., Accounting for Slower Economic Growth: The United States in the 1970s, Washington, DC: Brookings Institution, 1979.

Dillingham, A. E., The Injury Risk Structure of Occupations and Wages, Ithaca, NY: Cornell University, Unpublished Ph.d. dissertation, 1979.

DiPietro, Aldona, "An Analysis of the OSHA Inspection Program in Manufacturing Industries, 1972-1973." Draft Report to the U.S. Department of Labor, August 1976.

Doniger, David D., The Law and Policy of Toxic Substances Control: A Case Study of Vinyl Chloride, Baltimore: Johns Hopkins University Press, 1976.

Donovan v. Castle and Cooke Foods and OSAHRC, 9 Cir., 10 OSHC p. 2175.

Dublin, L. I. and A. J. Lotka, The Money Value of Man, New York, Ronald, 1941.

Fischhoff, Baruch, Paul Slovic and Sarah Lichenstein,

Graphem, John D. and James W. Vaupel, "The Value of a Life: What Difference Does It Make?" Risk, An Inter national Journal, 1, 1979.

Green, Laura, "A Risk/Risk Analysis for Nitrite," Working Paper, Cambridge: Massachusetts Institute of Technology, Department of Nutritional Food Science, 1978.

Hitch, Charles J. and Roland N. McKean, The Economics of Defense in the Nuclear Age, Cambridge: Harvard University Press, 1960.

Hodgson, M. and M. Meiners, "Loss of Illinois Metholodgy," A Guide to Milbank Memorial Fund Quarterly/Helath and Society, 60(3), 429, 1982.

Hoel, D. G., "Statistical Models for Estimating Carcinogenic Risks from Animal Data," Proceedings of the Fifth Annual Conference on Environmental Toxicology, Washington, DC, Government Printing Office, 1974.

Hutt, Peter B., "Food Regulation," Food-Drug-Cosmetic Law Journal, 33, October 1978.

Interagency Regulatory Liaison Group, "Scientific Bases for Identifying Potential Carcinogens and Estimating Their Risks," Report of the IRLG Work Group on Risk Assessment, 1979.

Jones-Lee, M. W., The Value of Life: An Economic Analysis, Chicago: University of Chicago Press, 1976.

Kaplan, R. M., J. W. BUsh, Berry C. C., The Reliability, Stability and Generalizability of a Heath Status Index," American Statistical Association: Proceedings of the Social Statistics Section, 704-708, 1978.

Keeler, Theodore E., "Domestic Trunk Airline Deregulation: An Economic Evaluation," in U.S. Congress, Senate Committee on Governmental Affairs, Study on Federal Regulation, Vol. 6: Framework for Regulation, Appendix, 96 Cong. 1 sess. Washington, DC: Government Printing Office, 1978.

Klausman, H, J. Francis, and G. Rosenthal, "Cost Effectiveness/Applied to the Treatment of Chronic Bond Disease, Medical Care, 6, 48, 1968.

Landfeld, S. and F. Seskin, "The Economic Value of Life: Linking Theory to Practice," 72(6), 555, 1982.

Landfeld, J. S., Control of New Materials with Carcinogenic Potential: An Economic Analysis, College Park, MD: University of Maryland, Unpublished PH.D. dissertation, 1979.

Lave, Lester B., Quantitative Risk Assessment in Regulation. Washington, DC: Brookings Institution, 1983.

Lave, Lester B. and Thomas Romer, "A Survey of Safety Levels in Federal Regulation," Washington, DC: Nuclear Regulatory Commission, NUREG/CR-2226, June 1981.

Lave, Lester, B. and Eugene P. Seskin, Air Pollution and Human Health, Baltimore: Johns Hopkins University Press, 1977.

________________________________, "Epidemiology, Causality, and Public Policy, American Scientist, 67, March-April 1979.

Linnerooth, Joanne, "The Value of Life: A Review of the Models," Economic Inquiry, 17, January 1979.

MacCarthy, Mark, "A Review of Some Normative and Conceptual Issues in Occupational Safety and Health," Boston College Environmental Affairs Law Review, 94, 1981-2, 773-814.

Mendeloff, John, "Problems in Valuing Health," Working Paper, Department of Political Science, University of California, San Diego, April, 1982.

Mendeloff, John, "An Evaluation of the OSHA Program's Effect on Workplace Injury Rates: Evidence from California through 1974," Report for the U.S. Department of Labor, July 1976.

Merchant, James A., "Cotton Dust: A Scientist's View," in Crandall and Lave, 1981.

Merrill, Richard A., "Federal Regulation of Cancer-Causing Chemicals," Draft Report to the Administrative Conference of the United States," Washington, DC: Administrative Conference, April 1982.

Mills, Edwin S., *The Economics of Environmental Quality*, New York: W. W. Norton, 1978.

____________ and Lawrence J. White, "Government Policies Toward Automobile Emissions Control," in Ann F. Friedlaender (ed.), *Approaches to Controlling Air Pollution*, Cambridge: MIT Press, 1978.

Mishan, E. J., *Cost-Benefit Analysis*, New York, Praeger, 1971.

Mishan, E. J., *Cost-Benefit Analysis: New and Expanded Edition*, New York: Praeger, 1976.

Morrall, John F. III, "Cotton Dust: An Economist's View," in Crandall and Lave, 1981.

Morris, Samuel

National Academy of Engineering, *Perspectives on Benefit-Cost Decision Making*, Washington, DC: National Academy of Engineering, 1971.

National Academy of Sciences,

National Academy of Sciences, Advisory Committee on the Biological Effects of Ionizing Radiation, *The Effects on Populations of Exposures to Low Levels of Ionizing Radiation*, Washington, DC: NAS, 1979.

Nichols, Albert, "

Office of Technology Assessment, "Assessment of Technologies for Determining Cancer Risks from the Environment," Washington, DC: Office of Technology Assessment, June 1981.

Office of Technology Assessment, "The Implications of Cost-Effectiveness Analysis of Medical Technology: Background Paper #1: Methodological Issues and Literature Review," Washington, DC: Office of Technology Assessment, September 1980.

Oi, Walter

Olson, C. A., An analysis of wage differentials received by workers on dangerous jobs, J. Human Resources, 1981, 16:167.

Policy Analysis, Inc., Evaluation of Cost of Illness Ascertainment Methodology, Part 1. Concepts, Issues and Methodology of Cost of .

Portney, P. R., Housing prices, health effects, and valuing reductions in risk of death. J Environ Econ Management, 1981, 8:72.

Rice, D. P., "Estimating the Cost of Illness Health Economics Services, No. 6, Publication 947-6. Washington, DC: U.S. Public Health Service, 1966.

Rice, D. and T. Hodgson, "The Value of Life Revisited," *American Journal of Public Health*, 72(6), 536, 1982.

Ruff, Larry E., "Federal Environmental Regulation," *Study on Federal Regulation*, Vol. 6, *Framework for Regulation*, Appendix, Senate Committee on Governmental Affairs, 95 Cong. 1 sess., Washington, DC: Government Printing Office, 1981.

Schelling, T., "The Life You Save May Be Your Own, in Chase, J. B. Ed., *Problems in Public Expenditure Analysis*, Washington, DC. The Brookings Institution, 1968.

Schultz, Charles, *The Public Use of Private Interest*, Washington, DC: Brookings Institution, 1980.

Schwing, Richard and Walter Albers, *How Safe is Safe Enough?*, Lexington: Ballinger, 1982.

Slovic P., B. Fischhoff, S. Lichtenstein, Rating the risks, Environment 1979, 21:14-20, 36-39.

Smith, R. S., The Occupational Safety and Health Act. Washington, DC: American Enterprise Institute, Appendix B, pp. 89-95, 1976.

Smith, Robert S., *The Occupational Safety and Health Act: Its Goals and Achievements*, Washington, DC: American Enterprise Institute for Public Policy Research, 1976.

Starr, Chauncy, "Benefit-Cost Studies in Sociotechnical Systems" *Perspectives on Benefit-Cost Decision Making*, Washington, DC: National Academy of Engineering, 1971.

Stasson, W. and M. Weinstein, "Allocation of Resources to Manage Hypertension," New Eng. J. Med. 296, 732, 1977.

Thaler, R. and S. Rosen, The Value of Saving a Life: Evidence from the Labor Market. In: Terleckyj, N. E. (ed.), Household Production and Consumption, New York: Columbia University Press for NBER, 1975, pp. 265-298.

U.S. Food and Drug Administration and U.S. Department of Agriculture, "FDA's and USDA's Action Regarding Nitrate," Draft Report, August 1978.

Viscusi, W. K., Labor market valuations in life and limb: Empirical evidence and policy implications, Public Poliyc, 26:359, 1978.

Wilson, James Q. (ed.), The Politics of Regulation, New York: Basic Books, 1980.

Zeckhauser, Ricahrd and Albert Nichols, "The Occupational Safety and Health Administration: An Overview," in Study on Federal Regulation, Vol. 6: Framework for Regulation. Appendix, Senate Committee on Governmental Affairs. 95th Cong. 1 sess. Washington, DC: Government Printing Office, 1978.

A Critique of Cost-Benefit Analysis As A Technique for Determining Health Standards Under the Occupational Safety and Health Act

Douglas MacLean and Mark Sagoff
Center for Philosophy and Public Policy
University of Maryland
College Park, Maryland 20742
April 1983

Table of Contents

Page

Introduction 1

The Justification of Cost-Benefit Analysis 4

1. Cost-Benefit Analysis Is Refined Common Sense 4

2. The Benefits and Costs of Reducing Risks Must Be Compared 6

3. Cost-Benefit Analysis Is an Objective, Comprehensive, and Natural Way to Determine Health or Risk Policies 8

4. Rational Individuals Would Consent Unanimously to Decisions Prescribed by Cost-Benefit Analysis 15

The Evaluation of Life and Limb 25

Feasibility Analysis 30

Notes 34

Introduction

We know more now than ever before about the dangers that surround us and the risks that we take. Our ability to detect hazards -- for example, to detect minute quantities of a pollutant -- has increased exponentially, so that we are aware of dangers that are not necessarily new, but of which we were ignorant. And we are more informed than ever before about what we do not know -- the dangers that might be there but cannot be measured.

Dozens of governmental agencies collect data on accidents, illnesses, and death. The Federal Highway Administration routinely analyzes traffic accident statistics to measure the safety of the highways; the Consumer Product Safety Commission monitors over a hundred hospitals to identify dangerous household products. The computers at the National Institutes of Health keep track of an enormous amount of epidemiological information to detect causes of diseases and death. The National Institute of Occupational Safety and Health works hard to identify and understand the hazards workers confront; the Occupational Safety and Health Administration analyzes data from the many workplaces it monitors.

All this information -- with the knowledge and uncertainty it creates -- presents problems and choices to the engineer in charge of designing a consumer product, the corporate executive who must decide whether to produce it and how to make it marketable, and the public official who must make sure it is safe. Likewise, workers, engineers, executives, and officials must make decisions that affect the safety and the environment of the workplace. The decisions we need to make -- the decisions before public officials, corporate executives, labor unions, and others who are responsible for public safety and health -- turn on the question: Which hazards are acceptable, which not, in what amounts, and why? No one believes that we can have a risk-free environment; perfect safety never existed and never will. We have never encountered, in any publication, an advocate of a no-risk society, save a few straw men created to make easy but ultimately unhelpful rhetorical points. How can we tell, however, how safe the workplace (or the highways or automobiles or tap-water, etc.) should be? And who should be empowered to make this decision?

During the past ten years, one way of answering these questions has become popular in academic circles, think tanks, and to some extent among public officials concerned with policy analysis. This approach borrows principles from cost-benefit analysis and applies them to the evaluation of risk. Those who defend this approach to policy analysis may do so because they believe the techniques of cost-benefit analysis can provide objective, neutral, and perhaps comprehensive answers to questions which are now settle primarily on moral and political grounds. Yet these techniques attract at least as many opponents as partisans. Many economists and, it seems, a great many politicians believe that no formula and no set of techniques can substitute for moral and political judgment. This essay explores some of the reasons the opponents of cost-benefit analysis give against its general application to public policy. We will look at the arguments against cost-benefit or risk-benefit analysis in setting standards for public safety and health both generally and, in particular, in relation to the standards OSHA sets for toxic substances in the workplace.

Arguments against the use of risk-cost-benefit analysis are easily divided into two kinds: the practical and the theoretical. Arguments of the first kind raise "technical" problems, e.g. problems that arise when techniques that look good in a text book or sound good in a lecture are applied in the maelstrom of public decision-making. The practical difficulties lie, first, in gathering enough data to "price" all the benefits and costs of a major regulatory decision. Even if this could be done, however, political biases and pressures, tight deadlines, the stringencies of legislation, the quick pace of techonological change, the vagaries of consumer tastes and preferences, and a thousand other uncontrollable events can distort methods that are developed under the laboratory conditions of academic theorizing. Cost-benefit analyses are notorious for their flexibility and their tendency to justify any desired conclusion. All this is well known, of course, to those who support the use of cost-benefit analysis. They argue that our awareness of practical problems such as these, however, helps us to resolve them. They say that in spite of these difficulties, the techniques they recommend promise a less biased, less "subjective," and more rational approach to regulatory policy than may be found in any alternative.

The second kind of objection strikes at the theory or at the philosophical basis of risk-cost-benefit analysis. This kind of objection sees as wrong-headed attempts to refine and develop cost-benefit analysis or to apply it to anything more complex than a public works project such as a dam. The problem is not arbitrariness or political manipulability, but rather that cost-benefit methods attempt to replace politics with "science," or moral judgment by a market analysis. Such attempts are not worthy of our culture or our democracy; the more we come to rely on cost-benefit methods, the more we fail to deal with the value judgments and political decisions we are responsible to make as a nation.

The next section of this essay discusses the claims and arguments that support the use cost-benefit analysis especially in its application to programs and standards for safety and health. We shall show that these arguments are unsound because they depend on false assumptions or otherwise fail to support their conclusions. Later in this essay, we shall argue in favor of an alternative to cost-benefit analysis, namely, feasibility analysis. This method, although it lacks the "scientific" pretensions of cost-benefit analysis and provides fewer opportunities to mathematicians, is superior to it on ethical grounds, on grounds of political theory, and on practical grounds as well.

The Justification of Cost-Benefit Analysis

During the last decade, discussions of cost-benefit and risk-benefit analysis have filled professional journals and economic texts. Many of these articles urge regulatory agencies and other institutions to use these techniques in setting health and safety standards. These arguments turn on a few basic ideas or claims. These are:

> Cost-benefit analysis provides an obvious and straightforward way to make tradeoffs and to compare competing values; it is an extension of common sense.
>
> Cost-benefit analysis simply makes explicit a process of valuation that we must in any case undertake.
>
> When properly used, cost-benefit analysis provides a neutral, scientific, objective, and comprehensive technique for making decisions that are otherwise left to emotional, "subjective," and partial political judgment.
>
> Cost-benefit and risk-benefit analysis provide rational means for reaching efficient social decisions; thus, each person may be presumed to consent to it insofar as he or she is rational.

Let us look at each of these claims.

1. Cost-Benefit Analysis Is Refined Common Sense.

This argument, as one of its critics wryly suggests, supposes that everyone who thinks about the pros and cons of any choice does cost-benefit analysis, like the Moliere character who spoke prose without knowing it.[1] Yet people who think about the pros and cons of something and people who "price" costs and benefits do very different things. Consider the following example. Suppose we wanted to evaluate a work of art or of literature. We *might* think in terms of its market price, that is, how much people would be willing to pay for it. Then we could compare that price, based on consumer preferences, with the amount it costs to paint or write. That is the cost-benefit approach. We might also submit the work to critical evaluation; we should then view it in aesthetic and cultural terms. It is plain that to discuss or to evaluate an object or a choice on its merits is not necessarily the same thing as to conduct an auction or to imagine what prices people would pay for it in a market. When we apply common sense to moral, political, and cultural problems, we think about these problems in moral, political, and cultural terms, and not just in terms of markets. Common sense, in this way, has little to do with cost-benefit analysis.

The underlying reason is this. Common sense allows us to think over decisions in terms of true and false, right and wrong, good and bad. It allows us, therefore, to mull over the reasons for believing that a course of action is right rather than wrong, good rather than evil, or that a belief is true rather than false. The cost-benefit analyst, on the contrary, has little use for any of these concepts; he or she decides in advance that efficiency, or something like that, is the only objective good and that everything else is just a "want" or a "consumer preference" that a market can price. If values and beliefs *were* just wants -- or if the reasons for them were just arbitrary -- then we should not *need* common sense or, indeed, moral or political judgment. We would then just talk about interests and let a market, or a cost-benefit analysis, make our decisions. We are not merely bundles of consumer preferences, however; fortunately, we are also thinking persons and citizens capable of thoughts, beliefs, ideas, and convictions which must be judged on their merits in political debate, not merely priced at the margin in markets. As long as we are persons with ideals and convictions -- as long as we do not conceive ourselves as bundles of wants -- we cannot rely upon cost-benefit analysis or let it take the place of moral and political judgment.

2. The Benefits and Costs of Reducing Risks Must Be Compared.

It is undeniable that our risk management decisions force us to make difficult tradeoffs. We simply cannot afford to reduce risks to the limit of our technological capacity; and other important values make competing claims on our resources.

What follows from these facts of life, however, is simply that we must weigh and balance all these considerations in our health policy decisions. These factors will include the economic costs and benefits of greater safety or improved health and many other values. What does not follow, at least not without further argument, is that cost-benefit analysis offers the best or even an acceptable method for weighing and comparing moral, political, cultural, and historical -- as well as -- economic considerations.

To our knowledge, no health, safety, or environmental legislation strictly forbids an agency from considering economic effects of its decisions. The Delaney Amendment to the Food and Drug Act, which regulates carcinogenic food additives, and the primary health standards of the Clean Air Act are frequently cited as examples of absolutist health legislation. It is sometimes charged that these laws could permit or even require us to regulate ourselves into ruin. The courts pointed out in reviewing OSHA's standard for mechanical power presses, however, that if a piece of regulatory legislation were to forbid an agency from considering economic impacts, it would most likely be unenforceable anyway.[2] The Delaney Amendment and the Clean Air Act, moreover, allow some discretion to the agencies in interpretation and enforcement, and the rulemaking procedures for setting standards permit all kinds of opposition to be expressed and felt. After all, we still permit saccharine to be marketed, and we have managed to delay enforcement of ambient air quality standards enough to ease the economic burden on an ailing automobile industry. Competing values are considered even without the benefit of cost-benefit analysis.

Cost-benefit analysis is hardly inevitable; we may choose from a variety of approaches to social decisionmaking. OSHA has developed feasibility analysis as a method for standard setting. This approach, unlike cost-benefit analysis, is consistent with the agency's enabling legislation. Regarding toxic substances, Congress requires OSHA "to set the standard which most adequately assures, to the extent feasible, . . . that no employee will suffer material impairment of health or functional capacity . . ."[3] OSHA satisfies this mandate by requiring an industry to make the workplace progressively more safe but not at such expense as would imperil its economic survival. To require safety at any cost, of course, would not be economically feasible; however, OSHA can determine this without having to balance benefits and costs. Feasibility analysis is one way of weighing economic considerations along with health considerations, but it is not the same as cost-benefit analysis. A proposed standard may be justified by a feasibility analysis yet not be cost-beneficial.

Later in this essay, we shall consider feasibility analysis in more detail, to show that it can be sensitive to costs without abandoning the purpose of the OSH Act -- which is greater safety, not greater efficiency. We shall leave further discussion of alternatives to cost-benefit analysis until that time.

Why, then, do many academic economists and lawyers along with some public officials call for the use of cost-benefit analysis? Why does it appeal to them as so self-evidently desirable that it requires little further justification? One can only speculate, of course, but it may be that the abstractness of the method, by which all values, concerns, interests, and effects are translated into preferences the satisfaction of which is to be maximized, leads people to think that cost-benefit analysis is more neutral and natural than it is. Indeed, some may think that our normal ways of weighing, judging, and deciding are simply imitations of cost benefit analysis, but without the precision needed to grapple with the complexities of regulatory decisions. We must consider the matter further, then, by turning to the third claim.

3. Cost-Benefit Analysis Is an Objective, Comprehensive, and Neutral Way to Determine Health or Risk Policies.

Cost-benefit analysis as applied to risk appeals to some because it promises to replace political controversy surrounding health regulations with a detached and scientific approach to making policy decisions -- an approach manages nevertheless to incorporate the interests that generate those troversies. Those who developed risk-benefit analysis generally intended to provide "an approach for establishing a quantitative measure for benefit relative to cost for an important element in our spectrum of social values -- specifically, for accidental deaths arising from technological developments in public use."[4]

Consider, by way of illustration, the Clean Air Act, which instructs the Environmental Protection Agency to set standards for maximum allowable levels of air pollutants. It calls for primary standards to establish levels which, "allowing an adequate margin of safety," are required "to protect the public health." In the last session of Congress, an amendment was proposed to change the requirement for standards to one that would protect the public health and welfare from "significant risk" of adverse effects. The author of the amendment explained that concepts like "safe" and "adequate margin of safety" are subjective, but that: "Risk, on the other hand, is amenable to objective quantification." He believed that, "before any major actions are implemented, they should be accompanied by rigorous risk analyses,"[5] which would protect us from the foolish and expensive excessive regulation to which the pursuit of an adequate margin of safety would inevitably lead. This same faith is expressed in the following blanket defense of cost-benefit analysis.

> The attraction of analytic methods (cost-benefit analysis, decision analysis) is their capacity to make explicit the assumptions, value judgments, and criteria used for making a decision. The analytic approaches are considered logically sound and sufficiently flexible to accept any value system. Given a specific set of values and criteria, a cost-benefit analysis could ideally indicate the decisions that would best balance technological risk and benefit (assuming that both tangible and intangible costs and benefits are included).[6]

This argument in favor of cost-benefit analysis correctly says that cost-benefit techniques make explicit the values underlying social decisions. In fact, these techniques require that social decisions serve or promote one specific value, which is to say, overall efficiency. The cost-benefit methodology explicitly assumes that what we wish to achieve as a society is the maximum satisfaction of preferences or interests of the sort that individuals might reveal in a market or for which they are willing to pay. The cost-benefit method weighs or compares these preferences according to their intensity, measured by willingness to pay, and then, in theory, reaches the result that would allocate resourcees in ways that maximize the satisfaction of those preferences. This, truly, is explicit. Those who recommend cost-benefit approaches to public safety and health advocate replacing the legislated goals of safety and health with the single goal of economic efficiency. But according to the Supreme Court in American Textile Manufacturers v. Donovan (the Cotton Dust decision)[7] and in other decisions, Congress has been equally explicit in rejecting efficiency as a goal befitting a society having our conventions, morality, and culture.

Cost-benefit analysis, nevertheless, attracts those who need to rely on a formula or who think that political argument or judgment is too "subjective" to be trusted. Those who like cost-benefit analysis because of its "objectivity" or "neutrality" might consider, as an alternative, this decision-procedure suggested to Jacob Horner, the protagonist of John Barth's novel The End of the Road. This procedure, which is very mechanical, recommends:

> If the alternatives are side by side, choose the one on the left; if they're consecutive in time, choose the earlier. If neither one of these applies, choose the alternative whose name begin with the earlier letter of the alphabet. These are the principles of Sinistrality, Antecedence, and Alphabetical Priority -- there are others, and they're arbitrary, but useful.[8]

This decision procedure is objective and it yields consistent choices. It is neutral with respect to any value system because it ignores them all. It is also insane. We simply see no reason to maximize Sinistrality, Antecedence, or Alphabetical Priority in making social decisions. Why do we think efficiency, which is the principle of cost-benefit analysis, is any less insane? Why efficiency? Why should resources be allocated in ways that maximize wealth or willingness to pay? No answer to that question is obvious. Thus there is no obvious benefit to choosing cost-benefit analysis from among the many objective analyses available to us.

The point is simply that an objective, analytic technique by itself is no great achievement. It is easy to cook up a method for churning out decisions. Everything turns, therefore, on *how* a proposed technique weighs different values. Is it *merely* neutral -- as one that ignores all values but "sinistrality" or "efficiency" would be -- or is it sufficiently sensitive to our important values as it attempts to measure and compare them all?

Without a decision procedure that aspires to the precision and rigor of a cost-benefit analysis or of formal quantitative risk analysis, we are likely to confront moral and political issues explicity in considering particular standards or in putting together the procedures of a particular agency. This will involve a process of argument and debate where contending sides try to convince a decisionmaker and justify some particular rule or standard. It can be a messy business, and the decision will turn out to be supported not strictly by computations but by opinions and judgments as well. But the lack of mathematical elegance does not mean that such a procedure is not an objective one. Reasons and judgments can be assessed on their merits, and the courts have indicated that they will review OSHA decisions to ensure that they have not been made arbitrarily.[9]

A quantifiable method might not be an improvement on such procedures at all. The points of controversy and the inputs of judgment will not be eliminated but may instead simply be moved to a different part of the process where moral and political controversies are rendered as benefits and costs. Such methods can make decisions worse; they hide political and ethical judgment behind a smokescreen of expertise. This is a central concern of the critics of cost-benefit analysis, one that is expressed, for example, in an oft-quoted remark by Lord Ashby:

> All attempts to rely on quantification, to create decisions out of computer scenarios, to deduce them from cost-benefit balance sheets, are likely to make the decisions worse, not better; for in the process of getting hard data, the fragile values, the unquantified information, the emotive elements which nourish public conscience, all run through the filter and are lost, and so the quantified information assumes an importance out of proportion to its real value.[10]

Lord Ashby's comments pose a dilemma for advocates of cost-benefit analysis. They must decide how to deal with ethical, political, and cultural values that are not traded in markets. They must decide, for example, how to count the guilt many Americans feel over the death of workers, indeed, the social outrage that citizens experience when they hear of very high death and injury rates. Are these social or community values simply to be ignored or, somehow, are they to be "priced"? Either alternative is unacceptable. This is a fundamental dilemma that cost-benefit analysis cannot escape.

As an illustration of this dilemma, consider the Reagan Administration's program for regulatory relief. A main instrument of this program, Executive Order 12,291, requires that agencies, to the extent permitted by law, accompany all major regulations with a Regulatory Impact Analysis, in effect, a cost-benefit analysis.[11] The Order directs the Office of Management and Budget (OMB) to review these regulations to assure that they pass a cost-benefit test. The Order, then, would require agencies not to promote clean water, clean air, workplace safety, or whatever, but economic efficiency, insofar as legally possible. The agencies, in other words, must pick regulatory objectives that "maximize the net benefits to society" and they must undertake action only if "the potential benefits to society outweigh the potential costs to society." The Regulatory Impact Analysis is to include (emphasis added):

> (1) A description of the potential benefits of the rule, including any beneficial effects that cannot be quantified in monetary terms, and the identification of those likely to receive the benefits;
>
> (2) A description of the potential costs of the rule, including any adverse effects that cannot be quantified in monetary terms, and the identification of those likely to bear the costs;
>
> (3) A determination of the potential net benefits of the rule, including an evaluation of effects that cannot be quantified in monetary terms; . . .

The Executive Order recognizes, as we see, that many beneficial and adverse effects of policies "cannot be quantified in monetary terms." These non-monetizable effects may be divided into three kinds:

1. Distributional or "equity" effects.
2. Life and death effects.
3. The emotive elements and fragile values that nourish public conscience.

All economists recognize that we stand as a society not simply for efficiency but, surely, for justice or equity as well. Thus, it matters to us not just that benefits outweigh costs but also that benefits and costs are distributed fairly. It seems that distributional or equity considerations underlie and motivate the OSH Act. Accordingly, a cost-benefit approach, since it cannot monetize and therefore cannot consider these effects, would be grotesquely inadequate to the purposes of the law.

A few economists, to be sure, have imagined that we could price equity "preferences" by asking how much people are willing to pay that goods be distributed one way rather than another.[12] We should then attempt to set a price on people's preferences about what others should have. This completely mistakes the nature of equity and justice, which depends on political and moral arguments, not on what individuals (e.g., including racists) happen to desire others to have. Equity is a matter of right or wrong; it is to be thought over and argued about. It is not a consumer service or a fungible good.

It is notoriously difficult to defend any assignment of an economic equivalent for changes in morbidity or longevity. All methods so far proposed -- lost future earnings, income differentials for hazardous work, willingness to pay for increased safety, and others -- have been roundly criticized for being unfair, arbitrary, and usually both. Similar problems arise when we look for monetary equivalents for increased fear, changes in the quality of life, aesthetic and environmental values, and many other concerns that need not raise equity issues. When OSHA issued its standards for coke oven emissions, it explained why it rejected cost-benefit analysis. It reviewed and discussed at length the alternative proposals for pricing human life. This section of the report concludes: "OSHA believes that these methodologies do not adequately quantify the value of life. Accordingly, we decline to do so."[13]

The failure of economists to find ways of "pricing" the beliefs and convictions we share as citizens, as distinct from preferences we satisfy as consumers, should not surprise us. The efforts they have made, however, must support the conclusion, recognized by Executive Order 12,291, that many important values cannot be monetized. If we allow, as the Order does, that not all the important costs and benefits of a regulatory decision can be expressed in quantified terms, then what possible reason could there be for insisting that regulations must pass a cost-benefit justification, which requires such a unitary yardstick for comparison? How can cost-benefit analysis claim to be either neutral or comprehensive if it cannot deal with a wide range of moral, cultural, aesthetic, and political concerns? There may be some issues which raise few important cultural or moral issues; for example, the commodities markets may be left to determine the prices of hog bellies or potash. This does not show, however, that markets or market analysis can give us an adequate policy for public safety and health. On the contrary, where moral, political, and cultural values -- not simply economic ones -- are at stake, we need to make moral, political, and aesthetic judgments. Cost-benefit analysis does not replace these "subjective" judgments with "objective" or "neutral" ones. Rather, it distorts or ignores the non-economic values it cannot handle. Thus we may understand Lord Ashby's concern.

We should point out, however, that to insist that some costs and benefits cannot be given a monetary equivalent is not necessarily to insist that market solutions to difficult tradeoffs are always undesirable. On the contrary, one may favor markets because they allow individuals to make their own choices for their own reasons, and thus take the responsibility out of the hands of the government. We worry only about the decisions that public officials make and ought to make, for example, decisions that importantly affect public safety and health. We believe that the reasons for those decisions are not always of the sort that can be registered in markets. We discuss these issues further in the next section.

4. Rational Individuals Would Consent Unanimously to Decisions Prescribed by Cost-Benefit Analysis.

Many economists and policy analysts who defend cost-benefit analysis argue that it offers a democratic, representative way of making decisions and of choosing policies; they argue that cost-benefit analysis (and, implicitly, the principle of efficiency it applies in collective choice) has our hypothetical, if not actual, consent.[14] They make this argument in either of two ways. They argue, first, that the efficiency criterion has our consent because it leads to or duplicates outcomes that individuals themselves would have reached in perfectly functioning markets. Markets, when they function well, that is, without externalities, free rider problems, and the like, are unanimous consent arrangements, since all transactions are voluntary. This first argument has the following form. It says that consent given in markets leads to efficient outcomes or allocations. Therefore, efficient outcomes or allocations, when determined by cost-benefit analysis, have our consent.

Second, those who defend the efficiency norm in decisions that affect public welfare argue that self-interested rational individuals should or would consent to it since they have a better chance to gain than to lose over the long run as a result. Efficient policies produce losers as well as winners, to be sure, and no one may be said to consent directly to his or her loss. Yet, since the efficiency criterion offers each person better odds on winning than losing, it seems that he or she ought to consent to the loss because it is fair (or perhaps efficient) that he bear it. At any rate, were individuals to choose ex ante (that is, before they know how things will turn out for them) between cost-benefit analysis and some other rule for social decision-making, they would choose cost-benefit analysis, because it gives them the best chance of ending up better off.

The popularity of laws like the OSH Act, the Clean Air Act, the Clean Water Act, and the Endangered Species Act, raise a fundamental problem for these arguments in favor of cost benefit analysis. These laws, enacted by a legislative majority, remain enormously popular. Yet they do not call for cost-benefit analysis; indeed, the Supreme Court has found, with respect to both the OSH Act and the Endangered Species Act, that these laws forbid cost-benefit analysis. Thus it is plain as can be that the citizens of the United States do not give their actual consent to the use of cost-benefit analysis in decisions about health and safety in the workplace and in the environment. A vanguard party of economists and policy analysts, however, argue that we give our "hypothetical" or "counterfactual" consent to efficient policies; they suggest we would do so, anyway, if we knew our own minds or interests. Why should we believe this political vanguard? Why do we not trust our elected representatives and even opinion polls instead?

The struggle for safer consumer products and a safer workplace, moreover, has been to a large extent a political struggle. This means, first, that consumers and workers look primarily to their elected representatives to satisfy their interests and to vindicate their concerns; they find less representation and less satisfaction in markets. Second, these groups have successfully enlisted public opinion, that is, the beliefs of citizens whose interests might not be served by a particular reform, but who thought it would be a good thing just the same. A lot of Americans have thought, correctly, that child labor is simply outrageous and contemptible, impossible in a society that considers itself in any way civilized, whether free market transactions would lead to it or not. Likewise, many Americans who are not themselves industrial workers condemn on moral grounds conditions in the workplace that cause a great deal of injury or death. Why should Americans, who have long been familiar with the political struggle to control the excesses of markets, now turn to markets and market analysis to make social decisions? Why, when we have long thought of health and safety in moral terms, should we "consent" to making health and safety benefits on the basis of economic calculations instead?

The principal reason we regulate safety in consumer products and the workplace is to prevent the mayhem that would result if we did not -- that could result and did result, one might add, in markets that appear to function fairly well. We regulate, in other words, for old fashioned utilitarian reasons: to prevent misery. We also regulate to prevent conditions which are simply outrageous, uncivilized, and beneath our dignity and self-perception as a caring and compassionate nation.

When it passed the Occupational Safety and Health Act of 1970, Congress estimated that 14,000 Americans had died in that year from job-related hazards. Congress found that of the nation's 79 million workers, over two million were disabled on the job and another 5 million suffered from lesser job-related illnesses. Almost 400,000 new cases of occupational diseases were reported that year. With body counts that high, Congress did not stop to ask whether markets were functioning efficiently, that is, whether workers and employers were contracting with one another freely and in an informed way. The Lochner era had long passed.[15] Congress really cared about health and safety -- it cared about thousands of lives and millions of injuries -- and not about how much workers were "willing to pay" for the safety employers might "sell" them. It passed a law, therefore, that calls for a safer and more humane workplace, not for more efficient markets.

It is always open to those who defend cost-benefit analysis, of course, to "discover" a market failure when they need one to justify an intervention really required on humanitarian or ethical grounds. The analyst, when the death rate gets too high, may speak, for example, of "third party" spillovers on widows and orphans. Later, we shall consider what happens to the definition of "efficiency" when externalities run wild in this way. What can be meant by a "perfect" market when anyone can find a transaction cost or a spillover to justify any governmental intervention on "economic" grounds?

The value of safety indicated by market transactions, e.g., in consumer products or in the workplace, moreover, is largely determined by regulatory policy. Higher "prices" paid for safety, in other words, result from regulation, which raises consciousness among consumers and workers. Bernard Kleinman, a negotiator for the Steelworkers, makes this point: "Safety is a very tough thing to negotiate. There are so many levels of consciousness to it. Both sides have to be hit over the head a good deal before they develop the consciousness that permits them to move."[16] It may not be unfair to say that through legislation we develop our consciousness -- our compassion, our pride, and our self-perception -- as a nation. As citizens, working through the rule of law, we force ourselves to change.

We are now in a position to see that consumer choices and political choices may be harder to assimilate than many economists apparently believe. Individuals appear to have one set of preferences they reveal about consumer goods and services in markets and another set of preferences or beliefs they express about matters of collective political and social concern, like workplace safety and health. It is hasty, therefore, to substitute cost-benefit analysis, which reflects consumer preferences, for political and ethical decisionmaking, which takes account of and judges the beliefs and concerns we entertain not only as consumers but as citizens. To what extent can cost-benefit analysis or market analysis measure our ideals and opinions not as self-interested consumers but as community-regarding Americans? We shall now consider this question.

Economists have long been aware of an apparent gulf between the preferences an individual reveals in consumer markets, on the one hand, and the values he or she expresses in opinion polls, in voting, and in the political process. The former -- consumer preferences -- tend to be grounded in the self-interested wants of the individual. The latter -- let us say, citizen-preferences -- tend to be grounded in the individual's community-regarding values and in his or her beliefs concerning what is simply right or wrong. Arthur Maass, an economist, clarified this point.

> An individual's response depends on the institutional environment in which the question is asked. . . . The market is an institution designed to elicit privately oriented responses from individuals and to relate those responses to each other. For the federal government, the electorial, legislative, and administrative processes together constitute the institution designed to elicited community-oriented responses.[17]

The gap between a person's consumer-preferences and his or her citizen-preferences (to continue to call them that) poses a severe difficulty for anyone who wishes to base regulatory policy on cost-benefit or risk-benefit analysis. The difficulty is this. We have seen that the advocate of cost-benefit analysis justifies its use on the grounds that it is representative -- more representative than the political process -- of our preferences. This argument depends, in turn, on the conception of markets as "unanimous consent" arrangements -- institutions in which each person gets to "vote" his preferences by paying to satisfy them. Yet we find that markets do not reflect the same preferences as does the political process. Markets reflect the wants or interests individuals are willing to pay for as consumers. The electoral, legislative, and administrative process together reflect the beliefs and opinions the individual is willing to argue for as a citizen. How can cost-benefit analysis present itself as better able than the political process to represent these citizen-preferences when it seems to ignore them entirely and fails to take them into account at all?

Economists who favor cost-benefit analysis (and some who do not) have responded to this criticism in several ways. The most extreme position, of course, would reject citizen-preferences altogether and insist that only consumer preferences should count in making and justifying regulatory policy. This extreme position would be impossible within the context of our constitutional democrary, since it guarantees citizens access to an electoral process. Our Constitution gives us the right to be heard -- to argue for our community-oriented beliefs and moral values. At the same time, the Constitution establishes the rights of citizens to privacy, freedom of conscience, and so on, in order to protect them from intrusive as opposed to aspirational and compassionate legislation.

Stephen Marglin, an economist, has considered and dismissed the idea that regulatory policy should be based entirely on consumer rather than citizen-preferences. He observes that the "Economic Man and the Citizen are for all intents and purposes two different individuals . . . market and political preference maps are inconsistent."[18] He then speculates:

> since deeds speak louder than words, one can argue that preferences revealed in the market place are more genuine and better considered. . . . One might argue on welfare grounds for authoritarian rejection of individual's politically revealed preferences in favor of their market-revealed preferences![19]

Marglin recognizes the "authoritarian" character of this rejection. The amount of political effort labor unions and supportive citizens groups exerted in favor of the OSH Act was considerable; that kind of activity involves as many "deeds" as "words". To reject the values individuals express through the political process, moreover, is to rule out the values those individuals can give reasons for and which they believe are worthy of community and perhaps universal acknowledgement. How can one suppose that these values are less considered or less important than those one reveals, often on impulse, often indifferently, when one selects a hairspray or buys a car?

Many who defend cost-benefit analysis try to account for citizen-preferences in another way. They argue that a person, to be "rational," must have only *one* preference ordering, not several for various contexts, e.g., citizen and consumer preferences. This definition of "rationality," however, has no basis except that it serves the purpose of academic economic theory. As one commentator notes:

> A person is given *one* preference ordering, and as and when the need arises this is supposed to reflect his interests, represent his welfare, summarize his idea of what should be done, and describe his actual choices and behavior. Can one preference ordering do all these things? A person thus described may be "rational" in the limited sense of revealing no inconsistencies in his behavior, but if he has no use for these distinctions . . ., he must be a bit of a fool. The *purely* economic man is close to being a social moron. Economic theory has been much preoccupied with this rational fool decked in the glory of his *one* all-purpose preference ordering.[20]

Finally, some economists have suggested that citizen preferences be regarded as "externalities" that markets fail to price. If a person believes that the nation should protect its workers or preserve its remaining wilderness, for example, then these harms count as a "spillover" or externality on his welfare. An ordinary citizen may feel guilt or remorse over high body counts in the workplace. His mere disapproval counts as a kind of suffering which he might be willing to pay to avoid. When one aggregates citizen willingness-to-pay for various policies, one might come up with a large figure indeed.

It is not hard to see that citizen preferences (sometimes called "intangibles" and "fragile values") cannot be priced as if they were externalities of public policies and investments. Here it suffices to point out that the concept of efficiency, if it has any meaning at all, must be defined in relation to markets that meet well-defined and well-specified conditions. These conditions, at least, must be identifiable. One of these conditions requires that a market, to define outcomes that are efficient, must be free of externalities or spillover effects.

When spillover effects are understood to consist in actual physical damage to person or property caused by a particular action or transaction, then we can tell whether there are externalities or not. When the concept of an externality "runs wild," however, to include any unpriced cost -- anything for which a person might be willing to pay but does not pay -- then no market and no transaction will ever be free of externalities. No way could ever be found, on that conception of an externality, to determine what is or is not efficient. One then engages endlessly in second-guessing consumer behavior and in speculating about citizen willingness-to-pay or one simply gives up the ghost of cost-benefit analysis and relies on the deliberation of elected and appointed officials instead.

We may conclude, then, that economists who defend the use of cost-benefit analysis have no way to take into account our values and preferences not as self-regarding individuals but as community-regarding and truth-regarding citizens. What does this suggest about the only argument or justification that can be given for the use of cost-benefit analysis, namely, that it is a democratic technique that represents fairly our will as a nation?

This argument fails because it assumes from the start that all choices are like market choices -- like choices among neckties -- in that these choices express only the interests of the individual as a consumer and not his or her ideas and beliefs as a citizen and as a moral person. To be sure, we give our consent *in* markets to the results of our consumer purchases, e.g., to the choice of a particular necktie. It does not follow from this, however, that we give our consent *to* markets -- or to cost-benefit analysis when markets fail -- with respect to every social decision.

Insofar as we view ourselves moral persons, on the contrary, we want our views and arguments to be *heard* and *understood*. To consent to cost-benefit analysis as the primary determinant of public policy is to consent, implicitly, to the conception the cost-benefit analyst has of us. It is to assume that we are intereted in nothing but satisfying our particular wants in the order of their intensity. We would consent to the efficiency norm in public policy, then, in order to maximize that form of satisfaction.

Plainly, we are concerned, however, with many other values besides personal consumer satisfactions. We care about equity, which is to say, the way benefits and costs are distributed. But we also care about other community values and moral and aesthetic principles having to do with the way we treat one another and the way we treat the natural environment. We care particularly that individuals be treated as persons, with respect and concern, and thus not merely as means to anything, including efficiency and the maximization of wealth. For these reasons, we could never consent to the substitution of cost-benefit analysis for the political deliberation through which we criticize and create the character of our lives not merely as individuals but as a nation.

So far, we have looked simply at arguments for cost-benefit and risk-benefit analysis as methods of social choice. We have found these arguments unconvincing. In the next section of this essay, we shall consider not the argument but the methods that cost-benefit analysts use. We shall see that these are confused and inadequate as well. Then, we shall turn to consider feasibility analysis. This strategy does not share the pretension of cost-benefit analysis. It does not pretend to set the goals -- the safety goals -- of our society. Rather, it suggests how goals set by Congress may best be achieved.

The Evaluation of Life and Limb.

Risk-benefit analysis offers a way of answering the question, "How safe is safe enough?" It proposes that things are safe enough to the extent that the risks associated with them are acceptable. It supposes, moreover, that these risks are acceptable insofar as the benefits they bring to society outweigh the costs. This answer invites two further questions. What social costs and benefits generally follow from programs or decisions that increase or decrease risks and hazards, say, in the workplace? Once we identify these costs and benefits, how do we measure or quantify them, so that they can be weighed or compared?

One reason for reducing risk, of course, is to save lives and to spare people from illness and impairment. How are these benefits to be measured? How can we assign a value to lives saved or lives lost? The question, put this way, is difficult -- or at least embarrassing -- to answer. Most people revere life; they think it sacred or priceless. One might argue, indeed, that life is a necessary condition for having values of any kind -- since no one can enjoy, appreciate, or believe in anything if he is dead. Thus, to ask how much a life is worth is to ask a perplexing question, since no one can value anything except on the assumption that he has his life.

Those who have developed the techniques of risk-benefit analysis are well aware of the metaphysical and ethical problems that vex any attempt to find out what a life is worth. Economists strive to avoid these problems by applying an economic value not to life itself but to improved health, longevity, or simply to the reduction of risk. In this way, economists avoid or try to avoid the dramatic but misleading possibility of "putting a price on life."

During the 1950s and 1960s the most common approach to the valuation of life was the so-called productivity or human capital technique. It prices each life lost at the value of the income that individual would have earned had his or her death been avoided. This way of attributing value looks on the individual's life as a resource the destruction of which involved a cost not to that individual but to society as a whole. It assumes that the individual's earnings represent his or her "marginal productivity," that is, the amount the individual contributes to the overall economic output. The loss of that output, then, represents the social cost of that death.

This way of assigning values did not work very well. First, it has no connection with individual willingness-to-pay to protect life and to reduce risk. It has no connection, therefore, with the arguments, such as they are, that attempt to establish the legitimacy of risk-benefit analysis. Second, this approach to quantifying benefits and costs fails to consider the social contribution a person makes when it is not measured by markets. Housespouses who are not paid, poets whose work is widely admired but who are poor, parents, etc., provide urgent social benefits that are not reflected in earnings. Third, this approach assumes markets measure accurately the social benefits provided by the goods and services that they do price, but this is plainly a false assumption. Finally, this approach values the lives of people in terms of their incomes -- which would be a morally impossible sort of measurement, even if, contrary to fact, it were objective and made economic sense.

In the late 1960s, economists led policy analysts in general in rejecting the idea that one may evaluate life in terms of livelihood. In a path-breaking paper, published in 1968, Thomas Schelling criticized as well as anyone might earlier attempts to estimate the value of a life, e.g., that of a child, as we do livestock, according to its contribution to the gross national product. Schelling moves the discussion from the evaluation of particular lives to the evaluation of statistical lives. He asks: "What is it worth to reduce the probability of death -- the statistical frequency of death -- within some identifiable group of people none of whom expects to die except eventually?"[21]

Economists, including Schelling, have sought to base an answer to this question on the preferences or the value judgments individuals reveal in their behavior, particularly, in markets. People make these judgments -- and thus reveal the value they put on safety. Safety devices are available, e.g., for the swimming pool or car, and the sales of these items provide one indication, at least, of the extent to which individuals are willling pay to reduce the risk of injury or death. A number of careful studies over the past twenty years have likewise tried to estimate the value of occupational risk on the basis of market data. These studies compare occupational wage differences against other variables, including risk levels. If the actual risks are known, more or less, to the worker or consumer, then it seems easy to derive an estimate of the cost of reducing risk and, in that sense, to assign a value X per life saved or death avoided. One may simply divide the wage differential or the price of a safety device by the difference in risk of premature death to the individual.

Let us assume that economists can derive a value X per life saved from the data collected from labor markets. Is this useful information? The following argument suggests reasons to conclude that it is not.

We pose the following dilemma. Either markets price risk correctly or they do not. If markets price risk correctly -- if workers and employers make voluntary bargains which are not troubled by externalities, transaction costs, etc. -- there is no economic rationale for regulatory intervention. If markets fail to price risk correctly, however, then market data provide no reliable information by which we can correct that failure. Thus it seems that a value X per life saved, derived from market data, would provide decisionmakers either needless or unreliable information.

Now, one may think that we can distinguish efficient from inefficient markets, and that we can use data taken from efficient markets to correct behavior in inefficient markets. Yet individuals are plainly willing to pay much more to avoid some risks than others, even though the risks are equal in magnitude. It may even be that in areas where markets function efficiently to price risks and where we might agree that the risk level ought to be set through consumer decisions, the acceptable levels of risk will differ systematically from those areas where we need and even want the government to determine acceptable levels.

This suggestion is based on what is surely true, that many different qualities of risk are important in determining our attitudes, not simply their magnitudes, i.e., the probability of injury or death. Voluntariness, of course, is one obvious distinction we want to maintain. But other, less obvious distinctions also matter. Some risks provoke greater fears than others; some seem to carry greater weight than others in determining whether we are showing adequate concern for human beings or the environment, which may justify extra precautions; some risks are connected to feelings that technologies control rather than serve us, while others seem not to bother us at all; and so on. If we take these concerns seriously, we are led to a very unsystematic conclusion. We may, as a society, choose to allocate resources differently to protect lives in different areas. It may be more important to us that public, government action make risk lower in some areas than it is in others. We may want to tolerate certain inefficiencies -- so long as they are not too great -- thus perhaps saving somewhat fewer lives overall than we could save, in order to target our actions to better conform with our many values. We simply do not want to rule out some possibilities from the start, without further thought and argument. Using market data to determine the value X per life saved, however, will not allow us to consider these further reasons.

Finally, the amount individuals are willing to pay for safety depends to a large extent on historical and cultural conditions which themselves may call for social intervention. Less than a century ago, when working conditions, by all accounts, were deplorable, the riskier jobs paid less, yet people were willing to take them -- and to send their children -- in spite of the fact that bitter experience made them aware of the hazards. One might obtain a very low value X in these circumstances, which were the shame of our cities years ago and still shame some cities today. What would this value -- a thousand dollars, perhaps, per life saved for a child "hurrying" coal in a mine -- tell us about regulatory policy? Is this a figure upon which social decisions ought to be based?

The question is not just a rhetorical one. One well-known estimate of worker willingness to pay for safety reflects data taken just prior to or at the time of the passage of the OSH Act. It estimates a relatively low value of life, around $300,000 as recomputed in 1978 dollars.[22] Later studies estimate an amount generally more than five times as great.[23] One may only speculate about the causes of this difference. One likely cause was the OSH Act itself, which, as we have suggested earlier, changed the "level of consciousness" about safety among workers and their employers. Thus, it appears that regulatory policies, far from being based on market data, in fact control those data, and these policies determine, more than they are determined by, the results of risk-benefit analyses.

We judge the acceptability of a risk in terms of all kinds of social, aesthetic, and moral characteristics. Some people see risks in the workplace, the environment, and consumer products more or less in political terms. They want to know who is responsible; they care much less about the benefits of the risky activity and the costs of reducing the risk. How can risk-benefit analysis take political, moral, and cultural parameters into account? It cannot. There is no way to extrapolate prices paid to reduce some risks (prices paid for safety in labor markets, markets for seat belts) to prices that ought to be paid to reduce other risks (prices paid for safety in nuclear plants). This is true because the social, moral, cultural, and political factors are not the same -- and these are the controlling factors. These attitudes and beliefs present a vast array of intervening variables which require a vast array of "double standards" to deal with risks that have different _meanings_ not necessarily different _magnitudes_. These attitudes, indeed, play a large role in determining what we think the magnitude of a particular risk is. To discuss the acceptability of a risky activity, like nuclear power, is to discuss a moral, cultural, and political problem -- not an economic one. The categories of risk-benefit analysis simply do not apply.

Feasibility Analysis

The proponents of cost-benefit analysis justifiably complain that their critics often fail to offer alternatives. The defenders of cost-benefit may concede that the method is not ideal in every respect. They may acknowledge many of the criticisms while still maintaining that cost-benefit analysis remains better than any other method for setting risk policy.

OSHA has developed an alternative strategy we believe is better in every respect. It takes account of economic considerations while still remaining faithful to the spirit of the OSH Act. It puts workers' health and safety above profits in setting OSHA standards, yet remains sensitive to the principle of diminishing returns. It has the further advantage of having been developed at OSHA rather than in the rarefied atmosphere of think tanks and universities. Surely, it speaks for feasibility analysis, as the OSHA approach is called, that the agency itself finds it a useful means for setting standards and for determining the levels of safety the laws requires.

The OSH Act simply and vaguely directs the Secretary of Labor to promulgate standards for exposure to toxic substances in the workplace that protect worker's health "to the extent feasible." OSHA was left to figure out how to apply this directive and, in particular, how to weigh economic factors against others.

OSHA's mandate, then, is not to balance benefits and costs to assure overall efficiency but to review scientific, technological, and economic factors to assure worker safety and health. As to the first, OSHA cannot wait for scientific proof that a particular substance is deadly; it need not tarry long enough until the body counts mount so high that everyone agrees upon the significance of the danger. Rather, OSHA may rely on indirect evidence, on the family resemblances among carcinogens, and, one hopes, a generic policy with respect to the assessment of risk, in order to identify a compound as dangerous. Plainly, OSHA has to exercise judgment, since dose-response curves are unknown with respect to many if not most suspected hazards. There is no way to rely on a formula rather than on "using one's head." The courts should -- and they have shown they will -- review OSHA decisions with more than minimal scrutiny to guard against arbitrariness and to ensure that the agency deals only with significant risks.

Similarly, the criterion for technology assessment does not have to depend upon the proven record of established technologies. OSHA regulations may be technology-forcing; they may require developments not yet realized but which are on the horizon. What is more, OSHA regulations may assure a market for companies that will then develop safety technology, thus encouraging a competitive approach that will make safety cheaper in the long run.

Finally, OSHA cannot help but recognize its responsibility to take account of compliance costs. It may look, therefore, for areas in which safety -- and therefore life and limb -- can be bought most cheaply. OSHA regulations need not equalize the marginal price of safety (or the unit price X per life saved) across programs, but if a program departs very much from this average marginal price, the agency should give an explanation. There are many reasons that we may wish, as a society, to "buy" more safety in one industry or in one area rather than another; what is crucial is not that OSHA maximize lives saved and injuries avoided but that it explain the reasons that it may not choose to do so with respect to particular hazards.

Feasibility analysis permits OSHA to respect the rule of law and thus to avoid replacing what Congress has decided with what some academic economists and political scientists recommend. To require the agency to practice cost-benefit analysis instead would be to substitute the rule of academic theory for the rule of law. It would no longer respect the institutions that make us a democratic, egalitarian, and open society. Cost-benefit analysis is not a way of regulating but a way of avoiding regulation. For OSHA to make efficiency rather than safety its goal, as Justice Marshall has suggested, would require "the American worker to return to the political arena to win a victory that he won before in 1970."[24]

NOTES

1. Steven Kelman, "Cost-Benefit Analysis: An Ethical Critique" *Regulation* (Jan./Feb., 1981): 33-4.
2. *American Federation of Labor, Etc. v. Brennan* 530 F2d 109 (1975) ("mechanical power presses"), at 123.
3. Occupational Safety and Health Act, section 6(b)(5).
4. Chauncey Starr, "Social Benefit versus Technological Risk," *Science* 165 (1969): 1232.
5. Comments of Congressman Broyhill, *To Breathe Clean Air: Report of the National Commission on Air Quality* (Washington, D.C.: March 1981), pages 5-5 to 5-17, at 5-8.
6. Chauncey Starr and Chris Whipple, "The Risks of Risk Decisions," *Science* 208 (1980): 1115.
7. *American Textile Manufacturers Institute v. Donovan* 452 U.S. (1981) (the "cotton dust"case).
8. John Barth, *The End of the Road* (New York: Avon Books, 1958), page 89.
9. *Industrial Union Department, AFL-CIO v. Hodgeson* 499 F.2d 467 (D.C. Cir. 1974), (the "asbestos" case) at 475.
10. We have not been able to trace the original source of this remark, but it is quoted by (among others) Rene Dubos, "Half-Truths About the Future," *The Wall Street Journal* (May 8, 1981), page 26.
11. Executive Order 12291, 46 Fed. Reg. 13193 (Feb. 19, 1981).
12. See Burton Weisbrod, "Income Redistribution Effects and Benefit-Cost Analysis," in *Problems in Public Expenditure Analysis*, edited by Samuel B. Chase (Washington, D.C.: The Brookings Institution, 1968), pages 177-222.
13. Occupational Safety and Health Administration, "Exposure to Coke Oven

Emissions," 41 *Fed. Reg.* 46751 (October 22, 1976).

14. Richard Posner, "The Ethical and Political Basis of the Efficiency Norm in Common Law Adjudication," *Hofstra Law Review* 8 (1980): 487-483

15. *Lochner* v. *New York* 198 U.S. 45 (1905) (invalidating a state law setting a 10-hour maximum and 60-hour weekly maximum for employment by bakers).

16. For this quotation and many others on "The Apathy Issue," see *OSHA and the Unions: Bargaining on Job Safety and Health*, Bureau of National Affairs Report (Washington, D.C.: BNA, 1973) p. 9, 14, 15.

17. Arthur Maass, "Benefit-Cost Analysis: Its Relevance to Public Investment Decisoins," *Quarterly Journal of Economics* 80 (1966): 213-219.

18. Stephen Marglin, "The Social Rate of Discount and the Optimal Rate of Investment," *Quarterly Journal of Economics* 77 (1963): 98.

19. Ibid.

20. Amartya Sen, "Rational Fools: A Critique of the Behavioral Foundations of Economic Theory," *Philosophy and Public Policy* 6 (1976-7): 335-6

21. Thomas Schelling, "The Life You Save May Be Your Own," in *Problems in Public Expenditure Analysis*, edited by Samuel B. Chase, Washington, D.C.: Brookings, 1968) p. 127.

22. Richard Thaler and Stanley Rosen, "The Value of Saving a Life: Evidence from the Labor Market," in *Household Production and Consumption*, edited by N.E. Terleckyj , (New York: National Bureau of Economic Research, 1975). The adjustments to 1978 dollars are computed in Martin Bailey, *Reducing Risks to Life: Measurement of the Benefits* (Washington, D.C.: American Enterprise Institute for Public Policy Research, 1980).

23. W. Kip Viscusi, "Labor Market Valuations of Life and Limb: Empirical Evidence and Policy Implications," *Public Policy* 26 (1978) 359-86.

24. *Industrial Union Department, AFL-CIO v American Petroleum Institute* 448 U.S. 607 (1980) (the "benzene" case) at 719.

April 15, 1983

NON-REGULATORY LEGAL INCENTIVES FOR THE ADOPTION OF OCCUPATIONAL SAFETY AND HEALTH CONTROL TECHNOLOGIES

Philip J. Harter

This paper was prepared under contract with the Office of Technology Assessment of the U.S. Congress. The views expressed are those of the author and do not necessarily represent those of the Office of Technology Assessment, its Board of Directors, its staff, or any of its advisory committees.

The extent of a firm's actions to improve the safety and health of its employees is influenced by many factors: The Occupational Safety and Health Administration of the U. S. Department of Labor may issue a standard requiring it to adopt control technology to meet a particular level of performance. Similarly, a state or local government may pass a law or issue a regulation directing the company to take action. OSHA may, even without issuing a standard, force the company to abate "recognized hazards that are causing or are likely to cause death or serious physical harm to [its] employees."[*]

The company may find that it is paying wage premiums for hazardous work that exceed the cost of reducing the risk through the adoption of control technologies. Or, it may find that the lost work time attributable to workplace injuries and illnesses costs more than taking action to reduce the toll. The firm may respond to the urgings of its employees, either in the form of a labor union or more informal arrangements.

The company may adopt control technologies to reduce its exposure to legal liability. It may act to reduce insurance premiums. It may purchase safer products from suppliers when obtaining new equipment because the suppliers seek to reduce their potential liability to the purchaser's employees. It may be a member of a trade association that advises its members to take certain precautions with respect to something common in the industry. Even without the trade association, it may wish to follow a voluntary standard recommending some sort of action -- sometimes specified and sometimes not -- to protect against a hazard. The firm may believe that following a standard is not so "voluntary" in that it will be enforced in some way or another. Finally, and most importantly, a company may adopt a control technology to protect its workers because it believes it is the "right" thing to do.

---

[*] Section 5(a), Occupational Safety and Health Act of 1970, 29 U.S.C. § 654.

On the other hand, a company may be reluctant to undertake an expensive program to reduce the incidence of illness and injury unless (1) it will be better off for having done so, in the form of reduced wage rates or improved productivity or the reduction of potential liability; or (2) it is reasonably confident that it will not be at a competitive disadvantage because its competitors will also incur similar costs (even then, a firm may still be reluctant because its income may be reduced due to a reduction in overall demand due to the increased price). Moreover, some of the factors that would appear to be a positive incentive for adopting control technologies may in practice actually inhibit their adoption, and some of the factors, such as product liability litigation, that sometimes act as an incentive for taking remedial action do not apply with full vigor in the workplace. Determining the net effect of the various incentives a company has for adopting control technologies, and for the related goal of compensating the victims of industrial accidents and diseases, is an enormously complicated and expensive undertaking; their complex interrelationships only makes the task more difficult. Our understanding of the actual effects of these processes, including direct regulation, is fragmentary at best.

This report is a survey of some of the factors other than direct regulation that influence a firm's decisions to adopt occupational safety and health control technologies and their interrelationships. It will review the salient aspects of product liability litigation as it affects the workplace, workers' compensation, voluntary standards, actions by OSHA other than direct regulation through specific standards, and the role of insurance. It will also highlight some of the major empirical questions for which research is needed to determine the relative efficacy of the incentive.

It must be emphasized at the outset that this report is designed to provide a basic understanding of the general principles of a wide range of complex, technical, often amorphous subjects. The limitations on time and resources mean that it is necessarily a survey. Because its purpose is to highlight the incentives a firm has to adopt control technologies, its perspective is from that of the company. That is not to say that the firm's perspective is right or that it leads to an optimal level of safety and health. The report does not advocate a particular point of view, but rather its purpose is to set corporate decisions in perspective.

Several of the topics vary state by state or company by company, in which case the general principles are described. Moreover, several of the topics are enormously detailed and others are still evolving. As a result, this report should be considered as an introduction or overview and not as dispositive with respect to any issue.

I

PERSPECTIVE ON POLICIES OTHER THAN DIRECT REGULATION

Limitations on OSHA. Congress enacted the Occupational Safety and Health Act of 1979 following a relatively steep rise in the rate of industrial accidents during the late sixties[*/] and in recognition of the virtual inability of any existing program to address the problem of occupational diseases, either in terms of prevention or in compensating those disabled by them. The Act's goal is "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions and to preserve our human resources...."[**/] To that end, Congress established a number of tools that could be used to address the problem, some quite specific but others more vague.[***/] The heart of the Act -- the primary line of defense -- is clearly the reliance on mandatory occupational safety and health standards.[****/]

[*/] The Labor Statistics indicate a rise of approximately 33% from 1965 to 1970. Smith [1], Figure 1, p. 8.

[**/] Sec. 2(b); 29 U.S.C. § 651(b).

[***/] Sec. 2(b) enumerates the policies that Congress expected would be used. An example of one of the vague provisions is "building upon advances already made through employer and employee initiatives for providing safe and healthful working conditions." Sec. 2(b)(4). While these efforts are no doubt to be encouraged, the Act did not provide much guidance as to how that would be done nor how to recognize those which should be enhanced; in short, it is hardly a mandate for specific action.

[****/] Interestingly, the list of available tools includes standards twice. See §§ 2(b)(3) and (9); see also, § 6, 29 U.S.C. § 655.

OSHA standards obviously play an important role in occupational safety and health matters, and they will continue to do so. It is important to bear in mind, however, that there are significant limitations on OHSA's ability to achieve its basic goal by writing and enforcing standards. Some of these shortcomings are:

- Standards almost always address unsafe conditions as opposed to unsafe acts. Yet, many accidents and, although probably less so, illnesses result more from the latter than the former. (To be sure, ensuring the safe condition can reduce the potential for injury or illness should such an act occur.) And, standards are relatively ineffective in securing a management commitment to health and safety which is critically important in addressing both conditions and acts.*/ Thus, the efficacy of standards is necessarily limited.

- OSHA, or any central agency, even under the best of circumstances will lack the resources to develop a comprehensive set of standards that address any but a small portion of the potential hazards of the workplace.**/ That problem is, of course, reduced to the extent performance standards encompass general categories of hazards instead of design standards applicable to specific conditions. Nevertheless, standards still apply to physical conditions, and OSHA cannot anticipate the variety of workplace hazards. With respect to occupational illnesses, OSHA cannot possibly develop standards governing exposure to the vast number of chemicals that are suspected of posing threats to human health. Gaps -- vast gaps -- will always exist in the standards.

---

*/ Smith [2] at 314. Harrison at 573. These authors point out that standards may reduce the circumstances in which an accident may occur, but they are generally effective only in those cases where the physical hazard is both permanent and sufficiently obvious or measurable for enforcement action. The Carter Administration's Interagency Task Force on Workplace Safety and Health surveyed the attributes of 40 successful safety programs and found that while standards and hazard control were frequently mentioned, "management commitment" is the most frequently cited program feature associated with good safety performance. First Recommendations Report at p. II-41.

**/ See, e.g. MacAvoy at 13-14, in which professional safety engineers estimated that OSHA's standards concerning machine guarding "encompass at most only 15 per cent of the various types of machines now in general use."

- Except in extraordinary circumstances, such as existed with respect to vinyl chloride, it takes years until an enforceable standard is in place. OSHA has probably averaged less than two standards per year since its creation and has developed only a handful of standards dealing with carcinogens and toxic materials. Moreover, it has consistently fallen behind in its program to renovate the safety standards it inherited at its creation. In short, standards writing at OSHA is a time-consuming, cumbersome process.*/ Thus, even in those circumstances in which OSHA believes the hazard is sufficiently great to merit a standard dealing with it specifically, the standard will usually not be effective for a long while.

- The overall effectiveness of a standard in securing the level of protection contemplated when it was developed is always open to question. One component of the concern is simply whether the standard will achieve the contemplated goal even if it were universally met. Another concern is the extent to which the standard's prescriptions are in fact achieved. The level of compliance might be low because the fines levied for noncompliance are relatively low and the likelihood of an inspection is likewise very low, especially for smaller businesses or those outside targeted industries. Thus, firms could well feel that from a purely economic perspective, the discounted risk of liability from a successful enforcement action is not sufficiently great to merit investment in expensive capital equipment.

---

*/ For these purposes at least this is certainly not to cast aspersions on OSHA nor to attribute fault nor cause to any party or interest; other agencies have had a similar difficulty in promulgating standards. It is only in recognition that writing standards takes a long time and consumes significant resources.

Thus, it seems clear that OSHA standards will never be able to address the full range of the problem. Moreover, standards raise problems of their own: they become outmoded; they frequently result in inefficiencies by prescribing a particular approach when the same level of protection might be afforded by less expensive means; they do not provide the firm with incentives to exceed their prescriptions; they can cause management to believe it has met its burden by complying with the standards alone.

The Role of Other Incentives. The inherent limitations of OSHA standards means that the stimulus for effective occupational safety and health programs must include forces other than OSHA itself. That is, firms must have reasons beyond OSHA standards alone to adopt strategies for occupational safety and health.

This report assumes that OSHA standards will continue to play an important role, especially for addressing particularly significant hazards to health. Its predicate is that other factors, such as those listed in the preceding section and those discussed in the report, may play an important role by providing the management of a firm with an incentive to take action. The design of an equitable, effective, and efficient occupational safety and health policy needs to pay careful attention to the efficacy of these other forces and how they interact or could be made to interact. These other incentives are too often ignored when thinking of occupational safety and health, and yet they play a major role. Moreover, if they are effective in providing a stimulus to management, their reach is beyond that accessible by OSHA.

The purpose of this report is, therefore, to review how several of the more prominent programs influence a firm's decisions and how they influence each other. As will be described, we are only now beginning to appreciate their nature and the full extent of their effect, so that we lack adequate data as to many important questions. What is important, however, is to appreciate their existence so that undue reliance is not placed on one approach -- OSHA standards -- without recognizing the limitations of that approach and the functioning of others. These other factors should be viewed as supplements, not alternatives, to direct OSHA regulation: each has its place.

The Goal. The goal of an occupational safety and health policy -- in all its components -- is to provide an "optimal" level of industrial health and safety. The quotation marks are included to highlight the difficult nature of the term. First, we sometimes think in the abstract that the goal should be total safety, or as much as can be achieved technologically. Yet, we recognize as individuals that we cannot live in a risk free society and that we readily incur risks everyday provided the benefits we receive in return are sufficient. Second, that observation is more complex in the occupational setting. In the usual case, the person incurring the risk also reaps the benefit, but the two are separated in the employment situation. One commentator provides the helpful example of an individual who readily subjects himself to the risk of driving to the beach for a day in the sun, as compared to the same person who drives to the beach to deliver goods for his employer; in the first situation, the person is directly free to make his own immediate judgment as to whether or not to incur the risk, but in the second case the direct benefit is received by someone other than the person at risk and that person is not as free to decide whether or not to go.*/ Third, the inability to translate health and safety concerns into dollars leads some to view them purely in moral terms and to denounce any consideration of economics in determining the appropriate level of safety and health. Yet, any method of doing so makes implicit economic trade-offs. The failure to recognize them as such sometimes obscures analysis.**/ Fourth, since resources are limited, from both the firm's and society's perspectives, if too much is invested in reducing a risk in one area, other risks will not be adequately addressed. Optimality therefore must also include a recognition that the investments in risk reduction must be spread across the variety of risks presented to reach an acceptable "portfolio" of risks. Fifth, the view of what constitutes "optimal" risk varies individual to individual. The value people place on risk aversion varies, and hence the trade-offs they are willing to make does also. Sixth, if too much is invested in risk avoidance the net welfare is reduced, including that of the putative beneficies, at least as a group. This is demonstrated by the extreme case of the totally safe workplace being one in which there are no people. Thus, the question of what constitutes an "optimal" level of risk is a complex task.

---

*/ Chelius, [2] at 3; this observation about the separation of risks and benefits ignores for the time being the question whether the person is paid a premium to incur the risk beyond what he would be paid if the job did not include it, in which case the two are not as separate as the description would indicate.

**/ This is certainly not to argue for setting standards or other health and safety actions on a rigid cost-benefit basis or any explicit monetarization of health or safety. It is mentioned only to recognize the existence of implicit trade-off that is one difficulty in finding the "optimal" level.

It is not the purpose of this paper to develop an economic theory of determining optimality nor for deciding at what level to set a standard. It merits brief discussion at the outset, however, for three reasons: One to make clear that it is inappropriate to seek a risk free workplace -- it does not and will not exist. Second, and more important for the immediate purpose, is that it provides some measure of the functioning of the forces described in the paper. Third, firms respond to economic stimuli.

The Cost of Accidents and Illnesses. One of the leading commentators on the relationship of law and economics of accidents has said, "it [is] axiomatic that the principal function of accident law is to reduce the sum of the costs of accidents and the costs of avoiding accidents."[*] This formulation has two components: The "primary" goal is avoiding accidents and illnesses in the first instance. The "secondary" goal is providing compensation for the accidents and illnesses that do occur. Its premise is that the law -- and other incentives -- should operate to minimize the total costs of avoiding accidents (and illnesses) and in providing compensation for those that do occur. Thus, under this formulation, a firm should invest resources, not just in hardware but in other commitments as well, up to the point where the investment no longer secures sufficient additional safety or health to reduce the cost of accidents and illnesses more than the invested amount. After that point it is "better" from a societal perspective to incur the cost of the accidents, since avoiding them would cost more.[**]

This guideline does not address several essential questions, however. First is that it posits the cost of an accident or illness, without deciding just what that cost is. Since the purpose of the equation is to determine the allocation of resources (including for a moment health and safety as a resource), it is essential if the proper allocation is to be achieved that the full cost of accidents and illnesses be included, not only a portion based on artificial limitation, such as workers' compensation, or only the portion that is easily moneterized, such as medical bills or direct loss of wages.

---

[*] Calabresi at 26.

[**] Note this formulation applies only to statistical risks and not to avoiding specific, demonstrable risks to identified individuals.

Because significant portions of these costs -- such as pain and suffering or death -- are not customarily expressed in terms of money, the latter cost must be approximated and a surrogate used. Thus, the "cost" of accidents and illnesses remains a controversial, difficult area.

The second major question the formulation leaves unanswered is who pays for the resulting accidents and illnesses. While, from a purely economic perspective, society as a whole may not be concerned with who pays since the goal is allocation of resources, the question is very real and very important for the individuals involved. Thus, the equity of the allocation is also important. And, it is also critical from the perspective of practical economics since the allocation of the costs is important in securing the achievement of the goal of minimizing the aggregate expenditures. That is, if a firm does not incur the costs of accidents, it will lack the incentive to minimize the aggregate costs.

The question of who pays has several other components. One concerns the transaction costs involved in shifting the burden from one party to another. That is, if one party incurs the cost initially but seeks to shift it to another, doing so is not costless. For example, an insurance company may pay out in claims only fifty cents for every dollar collected; the transaction costs in administering the system of reallocating the costs is therefore fifty cents. Thus, the transaction cost of reallocating the burden of accidents and illnesses must be included as a cost in and of itself.

Another aspect of the question of who pays is the tension between various goals. One goal is to assign the costs to the firm directly so it will have the requisite incentive to minimize costs. Another goal is to provide compensation to the victim. A third is a belief in sharing risks, which is generally provided by insurance. These goals are not always in harmony. For example, insurance can dull the firm's incentive; yet, requiring it can assure the resources to provide compensation; but, the transaction costs in securing compensation may mean that the full costs are not reallocated and hence not included in the formula; relying on "deep pockets" to provide compensation to someone who is injured may ignore whether the injury was attributable to the business activity or is more properly a form of social insurance. These questions can become highly complex. For purposes of this paper, the important question is simply to be aware of the competing goals and to measure the components of an occupational safety and health policy against them.[*/]

In sum, the goal of the policy should be a program that satisfies society's notions of equity and tends to reduce the aggregate costs of accidents and illnesses, including the costs of avoidance, the costs of the accidents and illnesses that do occur, and

---

[*/] For a more complete analysis of the complexities of the costs of accidents, see Calabresi and Posner.

the transaction costs involved in administering the system.

II

WORKERS' COMPENSATION

The Origin of Workers' Compensation. The common law during the late nineteenth century required an employer to take due care to protect its employees.[*] The employer was therefore obligated to act as a reasonably prudent man would if he were in the employee's situation. That meant that the employer must supply reasonably safe equipment, even if not of the latest design or safest available, and adopt reasonably safe work practices. A higher duty of care applied if the duties were particularly hazardous or the employees young or ill-trained. The employer was also obligated to employ a sufficient number of workers to accomplish the job safely. An employee could recover, at least theoretically, if an injury resulted from the employer's failure to discharge these duties. An employee could also recover from his employer for injuries resulting from the employer's negligence -- basically if the injuries were attributable to the employer's "fault".

But, there were important defenses to charges that the employer was responsible for an accident.[**] One was the "fellow servant" rule, which held that an employer would not be liable for the negligence of another employee (unless that employee was acting as the direct agent of the employer. Thus, if an employee was injured because another employee knocked him off a ladder or backed a train over him, the employer would not be liable. Nor would the employer be responsible if the employee's own conduct contributed to the accident. There would be no recovery, therefore, if the employee should have appreciated the danger but took no action to avoid it. For example, an employee injured by a machine could not recover if, by being more aware, he should have perceived the danger and been more careful to avoid it. The doctrine of assumption of the risk meant that, merely by accepting employment in the particular job, an employee also accepted the dangers that went along with it. Thus, he would be barred from recovering for injuries that were routine in the occupation. Finally, the lack of medical knowledge coupled with assumption of the risk meant few, if any, recoveries for occupationally related illnesses.

---

[*] Prosser, pp. 373-377.

[**] Prosser at 378-382. Chelius [2] p. 18; Ashford, p. 48; Darling-Hammond and Kniesner, pp. 7-8.

Reports from that period indicate that from 6 to 30 percent of workplace accidents were compensated by the employer.*/ Whether or not that figure accurately reflects the percentage of injuries that were the "fault" of the employer,[*/] the system was viewed as far too harsh on employees. Wherever the elusive "fault" might lie, the employee could have significant difficulty supporting himself and his family during his recuperation (let alone paying medical bills, or providing for the family's welfare in the event of permanent disability or death). In the formulation above, the costs of accidents were not factored into the equation nor was the distribution of costs viewed as equitable. Thus, a form of compensation in which fault was not relevant was substituted for the traditional tort remedy. The purpose of the compensation program was not to reimburse the worker for the full "costs" of the accident that he suffered, but rather to provide a floor under the loss of income.

---

*/ Chelius [2] at 19.

The United States lagged other industrialized nations in adopting compensation programs, and even then they did not come easily. Germany established a compensation fund in 1884 that was financed through compulsory contributions from both employers and employees.[**/] Great Britain enacted the "Workman's Compensation Act of 1897" that was paid for exclusively by the employers,

---

[*/] Chelius reports that a 1971 comprehensive survey by the Wisconsin Department of Labor, Industry, and Human Relations discovered that approximately 45% of the industrial accidents were attributable to careless behavior of workers; 30% were attributable to momentary hazards such as wet floors; the remaining 25% were caused by permanent factors such as unguarded machines. The latter number which appears to be the figure that would be traditionally regarded as the "fault" of management and hence within the reach of the tort law at the turn of the century, is strikingly similar to the compensation figures of two generations earlier. See, Chelius [2] pp. 8-9.

[**/] Darling-Hammond and Kniesner, at 8.

although they were permitted to obtain insurance with private companies.*/ By 1908 similar acts were in place in virtually all industrialized nations except the United States.**/

Several states adopted a form of compensation program in the first decade of this century, and Congress passed a compensation act in 1908 covering some Federal employees.***/ Several of the acts were declared unconstitutional on the ground that the strict liability deprived employers of property without due process of law -- which can largely be interpreted that the courts were hostile to any system of responsibility that was not based directly on their concept of fault. The Supreme Court also held that Congress could not pass a national workers' compensation program, so the individual states must decide whether and how to implement such programs. The programs were, as a result of this litigation, quite limited.****/

---

*/ Id.

**/ Id.

***/ Ashford, 48; Darling-Hammond and Kniesner, at 8-9. The evidence as to the impetus for the compensation programs appears mixed. Ashford, at 48, indicates that a series of substantial recoveries by employees caused businesses to support the programs. On the other hand, Prosser indicates, at 382, that the common law defenses were not abrogated judicially and remained in tact until the worker's compensation acts; firms could have been attempting to reduce their exposure from the accidents that did survive the usual defenses. Whether or not some businesses supported the concept, it is very clear that many opposed the acts bitterly and that that opposition had a substantial influence on how the compensation programs were put together and functioned.

****/ Darling-Hammond and Kniesner, at 9; Barth at 2; Ashford, at 49.

By 1979, all states and the District of Columbia had workers' compensation programs. But even then the early caution is clearly visible. In 1979, for example, in two states, coverage remained voluntary and in 18 coverage was a function of the number of employees.[*] Nonetheless, 87% of the labor force was covered by some compensation law in 1974.[**]

Workers' Compensation. Although the details vary state to state, under the typical workers' compensation program the employer is relieved of common law liability resulting from suits by its employees in return for paying a previously determined amount of compensation for injuries "arising out of" the injured person's employment. The compensation is awarded regardless of fault (and is therefore a form of strict liability). The benefits are usually two thirds of the employee's wages (up to a maximum level) plus medical benefits; disability, whether partial or total, is compensated according to a schedule; in the event of death, benefits are paid to the employee's heirs. Claims are processed in administrative hearings. The strict liability means that the primary issue is what caused the injury or illness -- did it "arise out of" the employment -- not who. A number of other issues are also submitted for decision, such as the extent of disability, the level of benefits, or whether certain exemptions apply. In one major survey, less than 10% of the accident clain were contested[*/] but a whopping 63% of the claims for occupational diseases were. In the contested cases, the injured employee represented himself in 84% of the accident cases, but in only a third of the disease challenges; attorneys therefore represent claimants in 66% of the disease cases but in only 15% of the accident cases.[**/] The employee's position was sustained after hearing in 13-15% of the cases, with the number being relatively the same for accidents and illnesses. Two thirds of the illness cases are settled by agreement whereas 55% of the accident cases are.[***/] Disease cases took 75% longer before the case was closed (404 days versus 233) after the first day of lost time.[****/] This does not mean it takes that long for the first check to arrive, but rather the time until a final resolution of benefits is made.

---

[*] Darling-Hammond and Kniesner at 78-79.

[**] Chelius [2] at 20.

The Problem of Occupational Diseases. The difference in the above numbers with respect to disease and accident cases indicates

---

[*/] Barth, p. 163. In a contested case, an employee's claim is denied by the employer, or, in the more general case, the employer's insurer. The employee then files a petition with the administrative board which decides the issues presented.

[**/] Id. The use of attorneys would, of course, reduce the ultimate recovery to the employee because of having to pay the attorney; on the other hand, their use indicates the complexity of the cases and hence the fact that their use undoubtedly increases the likelihood of recovery. Thus, the employee "invests" in a lawyer, but that increases the overall transaction costs of the system.

[***/] Id.

[****/] Barth at 167.

that the two have very different characteristics in the workers' compensation system. In fact, the distinction is even greater than they show:

> While all 50 states now provide coverage for occupational disease, numerous limitations on compensability exist. Many states, for example, provide full coverage only for those diseases "peculiar to the worker's occupation"; others exclude "ordinary diseases of life" even when such a disease might be shown to have occurred as a result of specific workplace conditions. Most states exclude infectious diseases. Nearly three-quarters of the states have "by accident" clauses that are applied to occupational diseases. These clauses require that the illness result from an unexpected event or exposure. Some states require that the toxic materials or working conditions that cause a disease must be solely or completely responsible for its onset. Many states limit occupational disease claims with rules relating to the duration and/or recovery of exposure and with provisions specifying time limitations for filing claims and manifesting the disease. The net effect of these limitations is that, by most accounts, only a tiny fraction of occupationally related disease cases enter the workers' compensation system. Those that do are the subject of lengthy contest, and they are typically resolved by "compromise and release" settlements.*/

Even if these hurdles are passed, it is often difficult to meet the burden of proof required for recovery. As Barth says, "The fundamental problem is the need to determine etiology: What are the cause and conditions under which the disease was contracted?"[*] The problems of occupational diseases that he discusses are the latency period of many diseases; the fact that many diseases have multiple causations, some of which are environmental; the etiology of a particular disease is unknown and hence it may not be known whether a hazard that contributed to it arose out of the employment; the exacerbating nature of stress; the uncertain course of cancer; and the difficulty in diagnosing occupationally-related disease.[**] Moreover, the definition of what constitutes an occupational disease and the scope of coverage are currently in flux, with the result being inconsistency and confusion over just what is covered and what is not.[***] Finally, programs typically erect evidentiary requirements to deal with some of the problems listed above, and they are often difficult to meet.[****]

---

*/ Darling-Hammond and Kniesner at 16. Barth's sample indicates that 55% of the disease cases are resolved by formal compromise and release agreements whereas only 16% of the accidents were. Barth at p. 167.

It is estimated that because of these difficulties only a small percentage of occupational diseases actually enter the workers' compensation system. For example, only 1% of all the compensation cases in New York that were closed in 1978 were for occupational diseases; they resulted in 3% of all compensation paid.[*****]

---

[*] At 61.

[**] Barth, Chapter 3.

[***] Darling-Hammond and Kniesner at 18.

[****] Barth, pp. 120-125.

[*****] Workers' Compensation Board, Compensated Cases Closed, 1978.

The average payment for occupational illness in New York in 1978 was $7,764 (as opposed to $3,210 average compensation for all cases). The largest average amount paid was $51,362 for "compressed air illness", with silicosis close behind at $48,620. Only three cases were closed concerning cancer, and the average compensation in those cases was $22,007. The 23 asbestosis cases had an average compensation of $35,882

It seems clear that the uncertainties of occupational diseases means that the compensation system does not perform the same function in this area as it does with respect to injuries, in which it provides at least some compensation relatively quickly and for relatively small transaction costs (in New York the payout has remained relatively constant at between 58-60% of the total premiums collected). Because the current system does not deal adequately with providing compensation for occupationally related diseases, several proposals have been made to broaden coverage. In part they would return to a schedule of compensable diseases, so that an employee who contracted a particular disease after being exposed to particular work situations would be presumed to be entitled to compensation.

The Incentives. Workers' compensation laws customarily require the employer to obtain insurance to cover related claims. If workers' compensation is to provide any incentive for an employer to provide a safe and healthful workplace, its insurance premium must reflect its prevention efforts, or lack thereof. This would, of course, obtain completely only if the company serves as its own insurer. It is approximated, however, when the premiums paid are based on the company's claim experience.[*] Generally, only large companies with a significant number of claims qualify for experience-based premiums. Approximately a quarter of all companies are eligible for this but, reflecting their size, they account for 85% of the premiums. Self-insurers account for another 14%.[**] Thus, it appears that the great bulk of employees are covered under workers' compensation programs that give at least some weight to the employer's experience with claims when setting premiums. These employers are therefore rewarded for taking actions to reduce the toll by reduced premiums, at least in the long run.

The sensitivity of this process is not clear, however, in that the reduced premium may lag the improvement by a significant period or may not fully offset the costs.[***]

---

[*] The question is addressed further in Section VI below.

[**] Chelius [2], at 26.

[***] Chelius has found that the strict liability was associated with a decline in work-related fatalities. Chelius [1]. The National Commission on State Workman's Compensation Laws found a "lack of clear evidence to support the theory that the present insurance pricing system reduces accident frequency." Quoted in Barth, at p. 51; emphasis added. The emphasis was added because there is some indication that the pricing of insurance has changed in the past decade to take more account of experience and on loss control activities than was the case when the Commission gathered its data. The extent of the incentive resulting from the pricing of workers compensation insurance, including large deductibles and self-insurance, is an important open question.

Whatever incentive exists to reduce accidents is likely to be much weaker with respect to reducing illnesses. That arises for two reasons: First, the experience thus far indicates that overall only a small percentage of diseases are compensated, so this cost is not figured into the calculations of the premiums. Secondly, because an illness may not manifest itself for many years, the payout that results from present actions is not made for many years. As a result, the company will not receive any benefits in terms of reduced payout for many years, and hence that potential liability will be significantly discounted in terms of present value. Thus, the company will not feel as much pressure to make investments currently to offset liabilities that will be felt far in the future. As a result incentives for dealing with diseases will likely have to come from other sources.

III

PRODUCTS LIABILITY

The Evolution of Liability. The law of product liability applies to the sale of goods, and hence on first impression it might seem irrelevant to a consideration of occupational safety and health. While not directly applicable in most workplace situations, product liability does in fact play an important role, and probably increasingly so.

The law held as recently as the turn of the century that a seller of a product owed no duty of care to those who purchased the product unless it undertook to do so by contract or the product was "inherently dangerous" in that it could cause grave harm if not manufactured correctly.*/ The case of MacPherson v. Buick Motor Co.,**/ decided in 1916, established the general principle that manufacturers have a duty to "safeguard life and limb" from injuries that are foreseeable if the product is negligently made. Thus, under this general doctrine, a defendant would be liable if it was negligent or "at fault," in that it failed to act in a "reasonable" way to ensure that its product was not defective. Unless the plaintiff could show just how the defendant's actions were unreasonable -- what action the defendant should have taken but did not -- he would be unable to recover anything. Moreover, if the plaintiff's actions contributed to the injury -- such as by using the product in an inappropriate way -- there would be no recovery; nor would there be recovery if the plaintiff knew of the risk and voluntarily assumed it.

---

*/ The common law imposed strict liability on ultrahazardous activities that could cause grave harm even if all due care were exercised. The case giving rise to the doctrine, Rylands v. Fletcher, 3 H.L. 330, an 1868 House of Lords decision, involved a reservoir that ruptured; another typical example is blasting. In these cases, liability was imposed for any damages resulting from the activity.

**/ 217 N.Y. 382 (1916).

Proving negligence could by its very nature be quite difficult -- how can a consumer prove what went wrong on a production line in order to show just why the product was defective? To meet this difficulty in proof, the law crafted evidentiary presumptions, especially the doctrine of res ipsa loquitur (the thing speaks for itself). Under this doctrine a plaintiff could argue that the product simply would not have been defective and in the condition that caused the injury unless the defendant were negligent. For example, the case giving rise to the notion held,[*/] in what is now surely not controversial but was at the time, that bags of flour do not fall from second story windows of factories unless someone erred; nor, to choose another, are mice in soft drink bottles unless the bottler did not take adequate precautions. The defendant could still rebut the presumption by showing it had taken all reasonable precautions -- i.e. that it was not at fault.

[*/] Byrne v. Boadle, 2 H&C 72 (Exch. 1863).

The second prong of liability rested on a contractual basis. The view developed that a seller implicitly warranted that the product would be suitable and safe for the purpose for which it was intended and indeed for all reasonably anticipated uses. A defective product would therefore be regarded as breaching the implied warranty and the plaintiff could recover. Whether or not the seller was at fault -- negligent -- is irrelevant under the theory of implied warranty since the very fact of the defect indicated a breach of warranty. But, the origins of the theory also contained its limitation: In contract law only those with whom a person deals directly are allowed to sue on the basis of the contract. Thus, someone who drank the soft drink with the mouse in it could not sue the bottler -- notwithstanding logic and judicial economy -- for the breach of an implied warranty, but rather must sue the store from which he purchased the bottle, which in turn would sue the wholesaler, which in turn would sue the bottler. Although even stating the requirement sounds absurdly formalistic and needlessly conceptual in avoiding the perfectly obvious result of imposing liability on the manufacturer, the courts wrestled with the issue of privity -- the required nexus between the injured and the one who caused the defect -- for decades. The arguments produced some of the most flowery judicial prose*/ and, in the process, legal fictions to get around the ancient limitations of privity and negligence.

---

*/ Ultramares Corp. v. Touche Niven & Co., 255 N.Y. 170 (1931).

Strict Liability. A concurring opinion of the Supreme Court of California[*/] during the mid-forties cut through the legal fictions and placed the question of liability in a new perspective: the manufacturer will be liable for injuries resulting from a defective product that is unreasonably dangerous, without regard to fault and without regard to the contractual limitations. This notion became known as "strict liability" since the degree of diligence or care in preventing accidents was immaterial. The matter was much debated in the courts and the academic journals for twenty years. Another California case gave it significant impetus in 1963.[**/]

The changed approach was based on three separate, but related theories: people who are injured by defective products should be compensated and the legal niceties make no sense in an automated, mass-produced society; secondly, the cost of accidents should be spread among those who benefit from the product, so that each user will pay a form of insurance premium to compensate those who lose in the lottery and are injured in the inevitable accidents; third, strict liability tends to optimize efficiency because the manufacturers are in the best position to reduce the total cost of accidents. These three reasons are often aggregated in the phrase that the cost of accidents is a cost of doing business and hence should be internalized to the firm.

[*/] Escola v. Coca Cola Bottling Co., 24 Cal. 2d 453 (1944) concurring opinion of Traynor, J.

[**/] Greenman v. Yuba Power Products, Inc., 59 Cal. 2d 57 (1963).

The highly influential American Law Institute, an advisory body consisting of distinguished lawyers, professors and judges, adopted this formulation in its now famous Section 402A of the Restatement (Second) of Torts in 1965:

> (1) One who sells any product in a defective condition unreasonably dangerous to the user or consumer or to his property is subject to liability for physical harm thereby caused to the ultimate user or consumer, or to his property, if
>
> (a) the seller is engaged in the business of selling such a product, and
>
> (b) it is expected to and does reach the user or consumer without substantial change in the condition in which it is sold.
>
> (2) The rule stated in Subsection (1) applies although
>
> (a) the seller has exercised all possible care in the preparation and sale of his product, and
>
> (b) the user or consumer has not bought the product from or entered into any contractual relation with the seller.

While the parts of the recommended rule are aimed at ridding the law of cumbersome doctrine, its primary thrust is that a manufacturer is liable to someone who is injured by a defective product that is unreasonably dangerous. Virtually every state has adopted this standard as the basis of product liability, although the former bases of product liability still live. Thus, a typical complaint will allege negligence, breach of warranty, and strict liability. Although the words are the same in most states, the interpretation of this section varies.[*]

Unreasonably Dangerous. Determining whether the product is "unreasonably dangerous" is a question within the traditional province of a jury. Notes to the Restatement make clear that in making the determination, "[t]he article ... must be dangerous to an extent beyond that which would be contemplated by the ordinary consumer as to its characteristics." This determination has a built in risk-benefit analysis -- does the utility of the product outweigh its potential risk to the user. Thus, a knife is not unreasonably dangerous because it cuts; nor is a drug because some people may have adverse reactions; nor is a VW van because it exposes the driver to a higher risk of injury in a head-on accident than does a standard sized, front engine automobile.[**] On the other hand, if the product poses more risk than is justified by its beneficial qualities, it may be unreasonably dangerous.[***] Courts regularly insist that strict liability does not mean the manufacturer is an insurer of the users of its product and hence responsible for any injury resulting from its use. Rather, liability attaches only if the injury is caused by a product that is unreasonably dangerous for its expected use. If the use is not reasonably foreseeable or if an injury results from a product that is not unreasonably dangerous, there is no liability, as the van case indicates.

---

[*] For an excellent non-technical review of the current state of product liability law, see Interagency Task Force, Legal Study.

[**] This example is from Dreisonstok v. Volkswagenwerk, A.P., 489 F.2d 1066 (4th Cir. 1974).

[***] For example, a small car need not be as safe as a big one in an accident since much of the protection is afforded by the sheer mass of the larger vehicle and the benefits of a small car would be foregone if it were made more massive. On the other hand, if the same benefits could be achieved with less risk, the product might be "unreasonably dangerous".

Individual's Conduct. A significantly difficult issue has been the legal effect of the plaintiff's own conduct. Because liability does not turn on fault, a defendant may not escape liability because the plaintiff's own negligence contributed to the accident. Thus, the defendant cannot argue that the injured person should have discovered the defect or guard against the injury's occurrence. But, what of the person who did in fact recognize the danger and proceeded to incur the risk? That has been the difficulty.

The law has evolved to bar recovery by someone who appreciates the risk and voluntarily exposes himself to it; in that case, he has elected to "assume the risk". In addition, however, the law also requires that the election be unreasonable before the plaintiff is barred from recovery. Thus, for example, the owner of a car was allowed to recover from its manufacturer when it went out of control even though he was told shortly before the accident that the steering mechanism was dangerously defective; the jury thought that his proceeding on was not unreasonable.[*/] The requirement that the assumption must be unreasonable is particularly applicable in workplace situations where an employee is generally not free to avoid a risk freely even if he perceives it. The defense of assumption of the risk is, therefore, not widely applicable in the product liability suits by employees against the employer's suppliers since even if they appreciate the danger they do not "freely" accept the risk because avoiding it would be difficult.

Because, under strict liability, assumption of the risk is an all or nothing question -- either the plaintiff assumed the risk or he did not -- there has been a movement to enact statutes that apportion liability depending on the degree of causation. Interestingly, these are called "comparative negligence" statutes. They apportion damages in proportion to the cause of the accident. Thus, for example, if a supplier sent a defective component to a manufacturer which included it in the final product and the purchaser recognized the defect and danger but proceeded to incur the risk, the jury could find under such statute that the supplier was 50% liable for making the defective part, the manufacturer was 25% liable for including it in the final product, and the buyer was 25% liable for incurring the risk. In that case, the plaintiff would receive 75% of the total damages incurred (which, in its own right is usually

---

[*/] Messick v. General Motors Corp., 460 F.2d 485 (5th Cir. 1972).

a judgment call by the jury). This doctrine is clearly a return to some sort of "fault" under the guise of causation.

The theory of strict liability is relatively straightforward with respect to manufacturing defects: There is a ready measure to determine whether the product is indeed defective because it differs from the manufacturer's own design. It becomes difficult, however, when applied to those situations in which the product is precisely as the manufacturer intended it. Two other forms of "defects" are recognized in products liability: marketing and design defects.

Marketing Defects. A marketing defect is a failure to warn of reasonably foreseeable dangers posed by the product.*/ As the discussion above indicates, determining whether a product is "unreasonably dangerous" requires a balancing of utility against risk; the "marketing defect" branch of the law indicates that the risk/utility question turns on the plaintiff's perception, so he can make his own choice as to whether to incur the risk. The fear is that the user may erroneously choose to use the product believing it poses a smaller risk than it actually does (or that he will reap larger benefits than he will in fact) unless he is adequately informed of those risks. Thus, the law imposes on the manufacturer or seller the duty to warn users about the risks posed by the product -- those that are inherent and those that would arise through particular uses. Something that might be regarded as "unreasonably dangerous" without a warning may not be with one since whether or not the product is unreasonably dangerous turns on the perception of the "reasonable" consumer.

---

*/ This can also include reasonable instructions as to how to use a product so as to avoid a risk of injury.

Since the putative function of the duty to warn is to provide the user with enough information to make an informed choice whether to incur the risk or take action to avoid it, it is a logical extension of the duty to warn that the manufacturer is under a concomitant duty to take reasonable actions to discover the hazards associated with a product and warn accordingly. Thus, a manufacturer cannot escape liability on the ground that it did not know a product posed a risk. Rather, it is obligated to test the product to determine its effect. As the court said in the case giving rise to the plethora of asbestos-related litigation:

> [T]he manufacturer is held to the knowledge and and skill of an expert. ... [This] means at a minimum he must keep abreast of scientific knowledge, discoveries, and advances and is presumed to know what is imported thereby. But, even more importantly, a manufacturer has a duty to test and inspect his product. The extent of research and experiment must be commensurate with the dangers involved.*/

It would appear from this body of law that companies have a relatively strong incentive to test their particular products and provide appropriate warnings. There is a Catch-22 of the requirement to warn, however: A warning can also be used as an admission that the product is dangerous, and it can therefore be used to find the very liability the manufacturer seeks to avoid by including it. This arises by the jury's finding that the manufacturer knew of a hazard and yet took no action to reduce it; that is, the manufacturer's own documents are used to show that it felt the product was in fact dangerous, thereby reducing the company's ability to meet the risk/utility argument. As a result, the incentive to warn is substantially offset by the adverse consequences that might flow from the warning itself. That is the case whether the warning is given at the time of sale or subsequently, after a problem with a product has been discovered.

---

*/ Borel v. Fibreboard Paper Products Corp., 493 F.2d 1076 (5th Cir. 1973) at 1089-1090.

Another logical problem with the duty to warn arises when even competent research would not reveal a hazard until long after the product is on the market. Chemicals posing a risk of cancer are prime examples because of the long latency period before any disease is manifested. The question then arises who bears the risk of this uncertainty? If, as the preceding discussion indicates, the manufacturer is obligated only to warn of those dangers that are reasonably ascertainable, the logical conclusion would be that the manufacturer had discharged its obligation by doing just that and the risk that a subsequent, but currently unknowable, hazard materializes would fall on the user. That may not be the case, however. The Supreme Court of New Jersey recently held that not knowing of the hazard, even if it was unknowable, is irrelevant.[*]

> [Defendants] assert ... that because they could not have known the product was dangerous, they acted reasonably in marketing it without a warning. But in strict liability cases, culpability is irrelevant. The product was unsafe. That it was unsafe because of the state of technology does not change the fact that it was unsafe. Strict liability focuses on the product, not the fault of the manufacturer.[**]

Thus, the court substitutes an objective test for determining whether the product is unreasonably dangerous. This decision -- while conceptually outrageous for its holding a company liable for failing to warn of something the court concedes is unknowable -- shows rather graphically that a "marketing defect" is really only a particular kind of "design defect:" liability is imposed because the product is dangerous, not for failing to warn.[***] The warning is relevant only as a determination of whether the risk is, under the circumstances, "unreasonable" and whether the user assumed the risk.

Design Defects. The concept of a design defect in strict liability tort law is that even though the product was made exactly as the manufacturer intended it, the design itself is defective and the resulting product is unreasonably dangerous. To avoid the intellectual disingenuity this entails, courts have said the product is defective because it is unreasonably dangerous. The notion is conceptually clear, however, in that the manufacturer failed to design the product adequately and, as a result, it posed an unreasonable risk to the user. An easy example is of a ladder in which the legs are not strong enough to bear the weight of a 100 pound person, or an automobile with brakes inadequate to stop in a reasonable distance. In both cases, the risk posed by the product was greater than anticipated by a reasonable user.

---

[*] The DES cases, which imposed liability on drug companies for second generation health problems, are a similar example.

[**] Beshada v. Johns-Manville Products Corp., 447 A.2d 539 (Sup. Ct. N.J. 1982).

[***] Another court rejected Beshada and found liability because asbestos is unreasonably dangerous, not for a failure to warn. Carter v. Johns-Manville Sales Corp., No. B-79-238-CA (E.D. Tex. 3/1/83).

But, what of the VW van mentioned above in which the plaintiff argued that the manufacturer should have taken additional precautions to protect a driver from an accident? Unlike the manufacturing defect case where there is a standard by which to judge performance, here it is entirely subjective -- should the manufacturer have designed the product differently so the accident would not have happened. The myriad trade-offs that go into designing a product are thus challenged as a jury second guesses the designer. For example, small cars will not fare as well in accidents as will large ones; is it therefore a design defect of little cars because cars as an entire category of products can be made safer?*/ One of the major difficulties of this area of the law is that in retrospect the product might have been redesigned in a way so the accident that did occur would not have. In that case, compared to the design advocated in the courtroom, the actual design might be regarded as "unreasonably dangerous." The question largely turns on what alternatives were reasonably available that would have prevented the injury but retained the desired characteristics of the product. Design defects are an enormously controversial area of product liability law.

---

*/ The question posed is, therefore, "As compared to what?" As the van case itself indicates, it may be unfair to compare the small car to the large one, but quite another thing to review the safety characteristics of the small car as such. In that case, the manufacturer might be held for failing to incorporate readily available safety features that would retain the benefits of the car as originally sold.

State of the Art. A defense to an allegation of design defect is that the design complied with the "state of the art." Under this defense, the defendant will argue that its product is no more dangerous than those of its competitors. That is, the product complies with the "state of the art" in the relevant industry. It is clearly evidence that the product is not "unreasonably dangerous" since the product comports with reasonable expectations about its characteristics; indeed, it is oftentimes conclusive on the issue. But, the entire industry may be slothful in adopting safety technologies. This argument gained its greatest impetus in a famous opinion*/ by Judge Learned Hand when he held that although it may be standard practice for tug boats in the New York harbor to go without radios, they were available (the opinion was written in the early thirties) and their use would have prevented the accident; thus, he held, even though the industry as a whole follows a practice, one company in the industry is still liable if an accident arises because a safer alternative was readily available.

---

*/ The T. J. Hooper, 60 F.2d 737 (2nd Cir. 1932).

As a result, the "state of the art" is not so much of a full defense as evidence that the action is reasonable.

On the other hand, if something is common practice in the industry and a company does not live up to that standard, it is strong evidence that the product is indeed unreasonably dangerous. Thus, for example, if several companies make power presses incorporating a particular form of guard and another company's machines do not offer as much protection, that can be used as evidence demonstrating that those machines are unreasonably dangerous since, after all, the competitors machines are safer. That is especially the case if the casual observer cannot tell the difference in the two situations and would reasonably believe both offer the same level of safety. But, if it is clear the second is not as safe, like the van, or adequate notice to that effect is given, the question reverts back to the assumption of the risk -- the buyer can choose whether to be a self-insurer by paying less and receiving less safety.

Another definition of "state of the art" that is also used in judicial opinions is that something is technologically feasible. "State of the art" in this connotation means the manufacturer has done all that can reasonably be done. In these cases, before "state of the art" is a defense, the manufacturer must show that it took all reasonably available technological steps to ensure the safety of the product. In that case a plaintiff would want to show that the safety design he advocates is feasible, meaning not just technologically possible but also that it can be incorporated without impairing the product's utility or making it too expensive.

The concept of feasibility, like the duty to warn, leads to another contradiction between what the law may intend and what happens in fact. The traditional rule of evidence is that a plaintiff may not use the fact that a defendant changed the design of a product as proof that the manufacturer conceded the original design was defective. The theory is to encourage designers to update their products and incorporate new safety technologies, and they would be inhibited from doing so if it were used as evidence against them. But, because of the concept of feasibility, the plaintiff may introduce the change into evidence to show that it is feasible to design the product in a way that avoids the hazard. Thus, the change is frequently presented to the jury willy-nilly, and no company can be confident that a safety related change in product design will not be used against it in product liability action.*/ As a result, not only does a manufacturer not get credit for improving the product, doing so may be held against it. That can in turn inhibit desirable change.

---

*/ The traditional rule is also breaking down in some state so a manufacturer cannot be confident that post manufacturing changes will not be introduced into evidence as a concession of a defect. Some courts also permit post-marketing changes to be introduced to show that the defendant knows of the product's dangerous properties.

The Problem of Disease. The doctrine of strict liability that imposes liability on a seller of an unreasonably dangerous product that causes injury to someone would seem to apply with full vigor to those products that, instead of causing injury, cause illness and disease. On first impression there is also good indication that that supposition is accurate: The first asbestos case, Borel v. Fibreboard Paper Products Corporation,*/ applies the typical strict liability analysis to find that asbestos is "unreasonably dangerous" and led to Mr. Borel's death; the court therefore imposed liability under § 402A of the Restatement. Liability has similarly been found in the DES cases, in which daughters of women who took DES during pregnancy developed cancer. Again, the chemical was found to be unreasonably dangerous for the purpose used and liability imposed. Also, there are numerous cases in which a product produces a more direct and immediate illness and the manufacturer is found liable for damages.

These series of cases would seem to indicate that the tort law is up to handling the problem of disease, including disease in the workplace. In fact, however, for very practical reasons, the line of cases has not developed and this remains a troublesome area. As one commentator wrote recently, "cancer victims nearly always fail to recover damages in tort because they are unable to meet traditional standards of proof."**/ Thus, the problem is not

---

*/ 493 F.2d 1076 (5th Cir. 1973).

**/ Note

so much with the law itself, but rather one of connecting the disease with the product, as the tort law requires.

These problems include:[*/] (1) proving a harm has actually occurred, since sometimes an unspecific malady may be attributed to general causes and not a specific substance or event; also, it may not be known whether even a specific disease, such as cancer, is attributable to "natural causes" or to some external reason. (2) Even if that hurdle is passed, it is often difficult to isolate one, or a cluster, of products that "caused" the harm; many products and situations may have interacted to produce the disease, and oftentimes the question of whether a particular product produces a particular disease is more a question of statistical inference than the direct proof usually used in the courtroom. (3) The problem of proof is often exacerbated by the passage of time, since the disease may not manifest itself for many years after exposure; the necessity for recreating one's life years before may make identification of a range of potential products difficult.[**/] (4) The etiology of the disease may be sufficiently uncertain that it is unclear whether the defendant's actions were

---

[*/] See, generally, Trauberman Chap't 1.

[**/] The asbestos cases present a relatively easy case in this regard since the workers generally knew from the outset what they were working with and hence there was little problem of identifying the substance in question.

the proximate cause of the disease -- i.e. the legal test for determining whether there may have been intervening causes or the connection between the substance and the illness was simply too remote. (5) It may be difficult to identify the company that made the product. That may be hard both because of the passage of time and because the product may be generic, so that even if the product could be identified the manufacturer could not. Under usual requirements, the inability to prove that a specific manufacturer made the product in question would be fatal and recovery would be denied. Recently, however, some courts have adopted the "enterprise theory" of liability in which all manufacturers of a generic, fungible product will be held liable in proportion to their market shares for damages resulting from the use of the product.*/ (6) In some states, but not in others, recovery would be denied outright if the disease manifested itself too long after the exposure; those states regard the exposure as the tortious conduct and then apply the customary statute of limitations to require that any suit be brought within a limited time (generally 3-10 years).**/

---

*/ This is the so called Sindell rule, named after the case giving rise to it, Sindell v. Abbott Laboratories, 26 Cal. 3d 588, cert. den. 449 U.S. 912 (1980).

**/ It should be noted that other states start the clock running only when the conduct is "discovered" so that the statute of limitations in those states would begin when the disease was identified. Other states use a "continuing tort" theory in which each exposure is regarded as a separate offense; that is used to get around the statute of limitations when exposure is continuous, but is unhelpful in reaching something that happened years ago and produced harm many years later.

As a result, there are very practical barriers to recovering for "toxic torts". And, as a result of that, various proposals have been made to alter the law to encourage more recovery. At the same time, the enormous number of lawsuits resulting from asbestos, and the resulting bankruptcy of some of the producers, does cause considerable worry among the producers of various substances -- even if liability for those substances has not materialized for the reasons described above. This potential liability has also sparked recent interest on the part of producers in some sort of "toxic tort" program.

Liability for Services such as Inspections or Consultation. The discussion thus far has focused on liability for defective products that cause injury or illness. The question also arises as to the liability for defective services. For example, someone who is injured by a machine following an inspection by his employer's insurance carrier could argue that the injury would not have occurred if the inspection had been more careful and detected the hazard. That person may, therefore, sue the company making the inspection, just as he would sue for a defective product, on the ground that his injury would not have occurred but for the negligent inspection.

Some courts have indeed imposed liability for defective inspections. For example, in Bryant v. Old Republic Ins. Co.[*/] the

---

[*/] 431 F.2d 1385 (6th Cir. 1970), putatively applying Kentucky law.

insurer was held liable for an inspection that should have discovered the defect in a mine that led to the death of a number of miners. Similarly, in U.S. Fidelity & Guar. Co. v. Jones[*/] an insurer was held liable for a negligent inspection that failed to discover the holes in a scaffold through which the plaintiff fell. Thus, there is the potential of liability.

These are not typical, however. The far more frequent case finds that an inspection conducted by a workers' compensation insurer as part of its coverage is protected from suit just as the employer is. The courts usually find the inspection is an integral part of the coverage and hence within the protection against suit that accompanies workers' compensation. Some states have reached this result by statute.

For those whose actions are not protected by the law against suits in the workers' compensation context, liability is generally defined by § 324A of the Restatement (2nd) of Torts. It provides:

> §324A. Liability to Third Person for Negligent Performance of Undertaking
>
> One who undertakes, gratuitously or for consideration, to render services to another which he should recognize as necessary for the protection of a third person or his things, is subject to liability to the third person for physical harm resulting from his failure to exercise reasonable care to protect his undertaking, if
>
> (a) his failure to exercise reasonable care increases the risk of such harm, or

---

[*/] 356 So. 2d 596 (Ala. 1977).

> (b) he has undertaken to perform a duty owed by the other to the third person, or
>
> (c) the harm is suffered because of reliance of the other or the third person upon the undertaking.

Liability in this case turns on negligence, the failure to exercise reasonable care, and so an inspector is not strictly liable for any accident that results from a hazard that might have been discovered. Even if the inspector or consultant is negligent, he will be liable only if one of the three conditions is met: his negligence actually increases the risk of harm; or, he assumes a duty that is owed the injured person by someone else (for example, someone who repairs a machine for its manufacturer); or, the injured person relies on the inspection or advice (for example, the injured person did not take action to protect himself that he otherwise would have because he thought it unnecessary since the other person determined the situation was safe).

Perhaps because of the general ban on suits resulting from workers' compensation statutes, there does not seem to be much litigation on this topic generally as it applies to the workplace.

Product Liability in the Workplace. The doctrines of product liability evolved rapidly since the turn of the century, and in particular in the past two decades, to take into account new perceptions about the allocation of risk and compensation. They are not, however, directly applicable to the relationship between an employee and his employer. Rather, an employee is usually barred from suing his employer for injuries or illnesses resulting from the workplace. As a result, the employee's remedy against the employer is generally limited to the benefits provided by the state's workers' compensation program. These benefits generally pale in comparison to successful product liability awards.*/ Thus, pressures have mounted for tort suits by employees for workplace injuries and illnesses.

Some of these suits are against the employers themselves, nothwithstanding the general ban. Workers' compensation statutes frequently allow an employee to sue his employer if the employer fails to secure the required insurance or qualify as a self-insurer. Such a suit is a traditional tort litigation, although the employer may not raise the traditional defenses. Some jurisdictions also permit suits against the employer for willful misconduct. Two other exceptions have also arisen.**/ Five states have recognized a "dual relationship" theory in which an employee injured by a product that is manufactured by his employer is allowed to recover from his employer on the basis of a product liability action, not because of his status as an employee. For example, an employee of a company making asbestos insulation would, under this theory, be able to sue his employer for diseases related to his exposure to the asbestos. Twenty-two states have rejected this theory, however. The second exception arises under statutes that do not preclude an employee from suing another employee. Sixteen states have permitted suits against corporate officials -- supervisors, managers, and the like -- but only in their capacity as employees of the company. Other states have held that such a suit is barred because in reality it is against the company, and some states have overruled by statute cases allowing such suits.

---

*/ That is at least in part intentional since workers' compensation was designed to provide a degree of certainty of recovery (although, as discussed above, that assurance may be illusory with respect to disease) in return for a limitation of liability. Thus, the benefits are not designed to cover the full cost of the accident, such as the total lost wages and pain and suffering that are included in tort suits.

**/ For an elaboration on the section that follows, see Biernbaum and Wreshel.

Product liability litigation has a greater impact on the workplace, at least in terms of the number of lawsuits, through suits by employees against their employers' suppliers. Workmans' compensation programs do not bar suits by an injured employee against the manufacturer of the product that caused the accident, and such suits have become relatively common. Moreover, in some states an employer (or, more accurately, its insurer) which pays a compensation claim is "subrogated" to the injured employee's right to sue in product liability for the accident. In that case, the employer sues in product liability. Thus, product liability litigation enters the workplace through the pressure on the suppliers of the products used there.

Product Liability and Compensation. The relationship between product liability litigation and workers' compensation has several difficulties. The first is that in products liability litigation the actions of the employer are frequently disregarded. Thus, a manufacturer of a substance may be held for failing to warn the employee of risks, even though it is the employer that is in the best position to know what products it will be using and for what purpose, to control appropriate work practices and to minimize exposure to the risk, and to make sure the employee is actually notified about any risks; indeed the supplier may not be in a position to warn since the product may not be marked by the time it reaches the employee. The employer may be in a position to prevent, or reduce, the harm and yet have little incentive under the law to do so.

A not infrequent example of the effect of not holding the employer responsible arises in cases in which a machine builder is sued for failing to install adequate guards on the machine, even though under the sales contract the employer had undertaken to do so and such a duty is imposed by regulation. In Borel, the court noted the chaos in which Borel worked, with asbestos spread all about; this form of exposure is directly attributable to the employer and yet was not relevant to the court's consideration of the supplier's liability. It would therefore seem more appropriate in assuring workplace safety that the supplier and employer have correlative duties and incentives to take appropriate actions. That would be the case if the supplier provided appropriate warnings to the employer, and the employer's conduct were then taken into account with respect to liability. The difficulty arises because of the disjunction of workers' compensation and product liability.

The second problem is really a corollary of the first. It is that it appears that the duties imposed on suppliers are greater than currently imposed on employers, since the latter's obligations have not kept pace with the developments of the tort law. To be sure, they remain liable for all accidents regardless of fault, and their preventative actions are sometimes rewarded in reduced insurance premiums and reduced wages, but they still do not have the same strong duties that are now imposed by products liability litigation as a result of full liability. As a result of the lack of synchronization between tort liability and workers' compensation, it may be that suppliers are providing a form of compensation via products liability litigation that more appropriately belongs to the employer. Inasmuch as the employer is in the far better position to ensure the safety and welfare of its employees than any supplier, or any standards writer for that matter, the distinction seems inefficient and misplaced. Proposals to integrate the two have been discussed from time to time, but little action has been taken short of expanding coverage of worker's compensation.

This is not to say either that the supplier should not bear part of the responsibility for ensuring a safe and healthful workplace nor that an injured or ill employee should not recover sums beyond those currently provided by worker's compensation. Rather, the question is how to apportion that responsibility to provide incentives for adopting the appropriate control technologies. There are, of course, very practical reasons for the suits against suppliers: First, the cause of the injury may have been the supplier's actions, in that the accident would not have occurred but for its actions regardless of the employer's conduct. This would be the case, for example, if the supplier failed to notify the employer of any dangerous properties of the product[*/] or if the product were "unreasonably dangerous" under any circumstances. Second, securing full compensation against some employers is sometimes difficult. The employer may have gone bankrupt. It may have gone out of business altogether. And, many feel that juries award larger verdicts against large, established firms than against smaller companies, so the possibility of more compensation for an injury or illness is usually felt to be greater if the defendant has "deep pockets."

The Current Controversy. A broad spectrum of manufacturers has felt that the enormous growth of product liability litigation

---

[*/] The court in Borel thought it was highly significant that the manufacturer had failed to warn contractors of asbestos' dangerous properties or of the standard recommending threshold exposures. 493 F.2d at 1086.

during the past fifteen years has imposed liability in some inappropriate circumstances, and they have mounted a substantial effort to revise the law through Federal legislation. They feel, for example, that liability is being imposed now for actions taken far earlier when duties were different; that courts have extraordinary vision in deciding what should have been foreseen; that they tend to focus singularly on a particular aspect of a product's design when determining whether the product suffers from a design defect, and in deciding whether plaintiff's own conduct was appropriate under the circumstances; that the enterprise theory of liability may be unfair to some manufacturers who did not make defective products; that the state of the art defense should be clarified; that products should be recognized as having a useful life and the companies should not be held responsible for products that have worn out. The argument is sometimes made that, notwithstanding the courts' frequent statements that a manufacturer is not an insurer, in fact liability is frequently imposed for injuries associated with a product as opposed to caused by it.

Others argue just as strongly that the tort law is evolving well and should not be tampered with. Moreover, they argue that the concerns are overdrawn, and indeed that the current law still erects formidable hurdles against recovery for illnesses with a long term latency.

As a result, the area of product liability, especially as it applies to the workplace, is currently a highly controversial area.

The question here is whether the respective parties have the appropriate incentives to provide a reasonable level of occupational safety and health. Thus, it seems appropriate to ask whether it would be appropriate to re-examine the respective duties. Tort law has moved into a new area by declaring, at least theoretically, that someone injured by an unreasonably dangerous product is entitled to recover the full "costs" of the injury. On the other hand, workers' compensation is still limited to a small fraction of those costs, albeit they can be secured at a smaller transaction cost. This appears to be out of balance with respect to providing the appropriate incentives*/ and would appear to merit reconsideration. Indeed, the problem with toxic torts may prove so intractable that we should look to an alternative way of providing compensation -- such as through a form of social insurance.**/

---

*/ This could, of course, be done by one of several means. The bar on tort suits could be lifted, at least in some circumstances. A form of comparative fault could be used in product liability litigation involving workplace torts, with the employer being one of the parties. The supplier could seek contribution against the employer for the proportion of damages attributable to the employer's conduct. The level of workers' compensation payments could be brought more in line with the current product liability recoveries. The role of the supplier in workers' compensation programs could be reconsidered, and the relationship between those programs and the tort law could be dovetailed more.

**/ See, e.g., Johnson.

To the extent one wishes to influence overall occupational safety and health, these questions should be joined in the ongoing examination of product liability law. The current law clearly has some unintended effects that harm the long run incentives to provide a safe and healthful workplace, and they too should be systematically considered. And, it seems essential that the question of toxic torts also be recognized as part of the same problem.

Incentives. The incentives provided by products liability litigation against suppliers, and in the few cases against employers, would appear to rest on the extent to which the company feels vulnerable to litigation; in that case they would have to discount the potential payout by the probability of a successful defense and the time until they would have to pay. That in turn would argue that it is an effective incentive when the transaction costs of the litigation are not great, at least in comparison to the potential recovery, and that the damages will be paid relatively soon. Thus, it would not appear to be effective with respect to disease since the transaction costs are high and recovery is often in the distant future; nor would it work particularly well where the damages are small and the injuries not sufficiently similar to merit joining them together in a class action. On the other hand, the enormity of the resulting litigation over asbestos can serve as a warning that must always be borne in mind. Workers' compensation appears to provide the incentive in cases where the cost of the accident is not great (the limitations of the system does, however, dull the stimulus of those cases) but is more routine.

What is needed is a careful examination of how the law actually works and the actual incentives it imposes to ensure that the respective players each fares the appropriate stimulus. Only then can the goal of optimal occupational safety and health, and the compensation for the injuries and illnesses that do result, be provided.

The Corporate Response. Whether or not the enormous changes that have taken place in the tort law over the past 20 years by the widespread adoption of strict liability have led to a significant change in the design of products is an inherently difficult question. Other factors are also at work. Products change in response to a change in demand, and clearly safety and higher quality products have been on the national agenda for about the same period as the explosion in product liability law. New technologies also afford new designs or existing designs at affordable prices. Moreover, product safety and occupational safety and health regulation expanded greatly during the same period. Thus, even if the safety-related changes in products could be documented, it would be difficult to attribute the changes to any particular cause. But, even ascertaining those changes is a resource-intensive effort since it would require assaying several product lines over a period of two decades to determine just what changes were made.

The Rand Corporation's Institute for Civil Justice has recently completed a major study on product safety and business decisionmaking. Its report will be published shortly and will provide the best glimpse we have into the corporate response to tort liability. The description that follows is largely based on an article by George Eads,[*/] a senior economist for Rand and a principle investigator in the study, from conversations with Dr. Eads, and from a review of a draft of the Rand study.

One thing is quite clear: The number of specific corporate units responsible for product safety related activities grew dramatically during the 1970's. The were fact of their existence would indicate that companies began taking product safety issues more seriously than in the past, and that in turn could be grounds for believing the level of safety increased in the respective products. One cannot proceed automatically from the existence of such units to increased safety, however. Rather, in addition to overseeing the safety of products, they may have the duty of enhancing legal defenses, reducing insurance costs, and providing a liaison with regulatory agencies.

[*/] Eads.

As Dr. Eads points out, the latter three functions may be only indirectly related to actual changes in design and increased safety. For example, design engineers widely agree on the need for carefully documented safety-related decisions, and many firms have installed formal policies to develop the documentation. But, companies also report that it is frequently difficult to get people on the line to do so and if a corporate unit fails to follow established corporate standards for a product it can be devastating in a liability suit. Even good documentation can show the company knew of safety questions but decided against incorporating them in the product on the grounds of cost, convenience, performance, or some other product characteristic. The trade-off may have seemed perfectly reasonable at the time of design and in the marketplace, but it takes little imagination to hear a plaintiff's lawyer telling the jury that the documents showed the company ignored the safety of its products by rejecting safer designs or recognizing that a certain number of injuries would result.*/ Thus, a company may couch safety decisions in euphanisms and not address the issues frontally. Or, a legally-oriented product safety unit may attempt to increase safety awareness but without leaving a paper trail that could be introduced into evidence; its purpose would be to make recovery more difficult, only one component of which is increasing the level of safety of the relevant products. In this case, while the unit may be active indeed, its effect on product safety may not be all that great or even negative.

---

*/ The problem facing the design engineer is perhaps most graphically demonstrated by considering a company that manufactures two versions of the same product, the economy and deluxe models. The economy one necessarily lacks some of the features of the deluxe version, since the entire purpose of taking the shortcuts is to reduce the price. The question then arises as to who pays for the accident that may result from the safety precautions not being taken? Phrased differently, who pays the insurance premium, the customer by the reduced price or the company by including in the cost of the product the appropriate premium. Strict liability would ascribe it to the manufacturer. It should be recognized, however, that doing so would deprive the customer of the option of being a self-insurer which may be done for less cost, especially if accompanied by increased awareness.

As the table reproduced in Appendix A shows, however, the great majority of companies surveyed do engage in a wide variety of activities directly related to product safety. Due in part to the relative novelty of product safety units, as well as traditional disagreements over virtually any management issue, there are several approaches to the product safety units. Some companies, noting the unit must necessarily monitor and resolve conflicts among a variety of corporate units -- marketing may resist overly explicit warnings or cumbersome safety-related features, advertising may go overboard in extolling the product's capabilities, production may resist stiff quality control programs, engineering may want to use particualr materials or components -- believe a committee approach is appropriate. Others find it helpful to appoint a single liaison that has the duty to provide coordination but little authority to impose it. Still others vest more control in the unit.

Next comes the question of the orientation of the unit. Some companies hold that many of its functions relate directly to legal issues, insurance, or regulatory problems and hence place it in the legal offices. More companies, however, give them an operational tilt because the output is largely technical and design oriented. The duties and orientation also vary depending on the nature of the company involved and its style of management. As the Appendix shows, some functions are exercised at the corporate headquarters level, some at divisional, and some at more local levels.

All in all, about the only generalization that can be made is that companies have increased their awareness of product safety related issues over the past two decades and established managerial units to deal with the heightened concern. The location, function, and effect of those units varies widely, however. And, importantly, one cannot say with assurance that the level of safety has actually increased.[*/] Certainly another potential effect of the expansion of tort law could be that companies refuse to market new products that could cause injury if improperly used or if they should fail; or they could build in safety features many buyers would choose not to purchase for fear that if the choice is provided a court will nonetheless hold that an injured plaintiff did not assume the risk.

[*/] Even if the level of safety has not increased that does not indicate that the expansion of the tort law has failed. Part of its purpose is to afford compensation and to spread the cost of accidents in an efficient way. Whether the overall cost of accidents (avoidance plus compensation) has been reduced and an effective means of spreading the risk developed remain vitally important questions.

Clearly the challenge is to provide incentives to take safety and health factors into account without unduly skewing the decision process away from making reasonable judgments as to product safety. Taking actions solely to avoid litigation costs and reducing product choice for those able and willing to make the decision seems in no ones interest. This, again, calls for a careful assessment of the respective incentives.

IV

VOLUNTARY STANDARDS

Another influence on a company's decision to adopt occupational safety and health technologies is the set of applicable voluntary standards which are influenced in their own right by product liability and workers' compensation exposure. Tens of thousands of these standards have been developed in the private sector.*/ Some are purely advisory and have very little legal effect;. some, while "voluntary" in that they have not been adopted by a government agency as binding regulations, are de facto mandatory either because the marketplace demands adherence or a government agency will use them as guidelines when enforcing general requirements.**/ Many of these standards apply to workplace situations. For example, there are standards for machine guarding; standards for labeling chemicals and providing warnings; standards for work processes in various industries; standards for testing materials used in the workplace; standards for electrical systems used there; standards for products used in the workplace; and so on. Indeed, for virtually any product or process some standard applies.

---

*/ Some standards that are developed in the private sector are subsequently used by agencies as the basis of mandatory regulations. Thus, while such a standard may start life as a "voluntary" standard in the common parlance, it is in fact obligatory. The clearest example of such a standard is the National Electric Code which is developed under the auspices of the National Fire Protection Association and which purports to be the most widely adopted model code in the world. It forms the basis for state and local regulation of household and commercial electrical systems. See generally, Harter [4].

**/ For a description of this process, see MacAvoy. A guideline is usually used as a measure of determining whether someone complied with a general performance requirement. The firm in that case is not required to adhere to the guideline but often does so because it is an acceptable method of compliance; a firm can meet the general requirements by some other means. The existence of the guideline exerts a pressure, not a duty, to conform to its requirements.

Standards Writing Organizations and Procedures. Standards are developed by a wide range of organizations and under a variety of procedures. This diversity is vividly illustrated by the National Bureau of Standards' Directory of United States Standardization Activities*/ published in 1975 that abstracts the standardization activities of 506 technical and non-technical, trade, and professional organizations; 26 state agencies; and 50 Federal agencies.

As an example of the standardization actions of a trade association, the Air-Conditioning and Refrigeration Institute**/ develops standards for equipment (physical and operating characteristics of items and equipment); testing (procedures for testing equipment to determine performance and operation characteristics); rating (for converting data into general statements of capacity and performance; application (specifying acceptable installation criteria including selection of equipment); and safety (provisions to safeguard life, health, and property). ARI also administers a certification program for some types of equipment; these programs use a "seal of approval" for equipment complying with applicable standards as validated by an independent laboratory.

---

*/ Chumas.

**/ Chumas at 5.

As an example of a professional organization, the American Society of Mechanical Engineers[*/] has 90,000 members and the development of codes and standards is an important part of its efforts to promote the art and science of mechanical engineering. Its Boiler and Pressure Vessel Code is followed virtually universally in controlling the risk of the explosion of boilers -- what was once a common occurrence exacting a large toll in the workplace has, due in large part to this code, been enormously reduced.[**/] More than a dozen Federal agencies participate in its code activities.

The National Fire Protection Association develops standards ranging from the National Electric Code, which exerts a pervasive influence on the safety of electrical wiring, the Life Safety Code, having to do with the design of buildings in general, on to standards governing the safety of specific products or processes such as liquefied natural gas or fire brigades in factories.

[*/] Id. at 43

[**/] The Boiler and Pressure Vessel Code has been adopted by 46 states and all but one of the Canadian provinces.

Independent testing organizations also establish product and process standards. The organizations then use these standards for determining whether to "approve" the product or process. As the National Bureau of Standards' Directory describes Underwriters' Laboratories activities, approval "is applicable to those products which have been evaluated with respect to all reasonably foreseeable hazards to life and property, and where such hazards have been safeguarded to an acceptable degree."[*]

The procedures used to develop the standards also vary widely. At the bottom of the scale, some are undoubtedly issued by a single person or a small group that sets out its view of how things ought to be. The standard may also reflect the views of a broader group sharing a common interest. For example, a standard issued by a trade association will likely reflect only the position of its members. A standard issued by a professional society, on the other hand, also may reflect only the views of the members of the society, but the members occupy a range of economic interests and are bound together by a professional goal. As a result, the standard will likely reflect a broader viewpoint than one initiated by a group with a relatively uniform economic perspective. A standard may also be devleoped by representatives of all interests that would be significantly affected by it.

---

[*] Id. at 162

These latter standards are frequently referred to as "consensus" standards if, in addition, they are developed under procedures ensuring a consensus among a diversity of viewpoints. While the details of the various procedures vary, there is virtual agreement on the general principles:[*/]

-- Reasonable notice that a standard is being considered is provided to those who may be interested in its subject matter.

-- Representatives of those interested in a standard are able to participate effectively in its development through membership on the committee that is responsible for preparing a draft standard, and no one interest dominates the membership of the committee (This is known as a requirement that the committee be balanced).

-- A method is provided for receiving and fairly considering the views of those who are interested in and affected by the standard during its development process.

-- The standard reflects substantial agreement of all interests concerned following a concerted effort to resolve objections; this consensus implies more than

---

[*/] For a more general discussion of the development of standards, see Harter [4]. Just as during the past fifteen years great attention has been paid to the procedures by which agencies develop regulations, similarly the process by which standards are developed has received close scrutiny. As a result, the procedural quality of consensus standards has likely increased significantly during this period in terms of access and resolution of issues.

a simple majority of those voting, but less than unanimity.

-- Written records of the discussion and decisions that were made concerning the standard are kept and are available for public inspection.

-- A right of appeal to higher authority is afforded those who feel aggrieved by action taken during the standards development process, such as an allegation that a committee is not adequately balanced or that a valid substantive objection was not adequately considered.

While many standardization activities are open to participation by all affected interests, it is not uncommon for some interests to be underrepresented.*/ Although it is often said that unions frequently are because they regard standardization as being under the control of management, some are active participants in standards of particular interest to their members, such as the National Electric Code. Consumer and environmental interests are also frequently underrepresented because of the expense involved in participation, and the representative organizations have to husband their resources to participate in only those of major consequence. It is also alleged that small businesses are underrepresented. Some standards writing organizations, such as the American Society of Testing and Materials, have subsidized participation by public interest groups and small businesses.

---

*/ This paragraph is basically impressionistic in that it results from numerous conversations. It is, therefore, overally generalized and no research has been conducted to validate it in general terms. It should be noted that the general observations vary widely with respect to individual standards. Hence, the composition of any standards writing committee should be checked before making a judgment as to the diversity of interests represented on it and no assumptions should be made.

Government agencies are frequently represented in standard setting, both as participants and as observers. The Carter administration issued guidelines setting out when agency officials could participate in the process; the conditions were largely that the process must be an open consensus process as described above. The Reagan administration revised those guidelines to expand both government participation and the use of standards developed in the private sector; it also deleted the "due process" requirements, although it noted that an "improperly conducted" standardization process can have adverse effects on a diversity of subjects including health and safety.*/ Some agencies allow their officials to participate as full, voting members on the committees, while others prohibit their employees from voting on the ground that a vote will be inevitably misconstrued as an official agency position when in fact it is not.[*/] Some agencies have formal procedures that must be followed before an employee participates, while others permit employees to participate as a routine aspect of their duties. Some agencies work closely with standards organizations in providing data and comments, others do not.

---

*/ §7, OMB Cir. A-119, Revised October 27, 1982.

The American National Standards Institute (ANSI) serves as a general coordinating body for standardization activities, and it will list a standard as an American National Standard if it is in fact a consensus standard. ANSI either reviews the process by which the standard was developed to determine whether it meets the above criteria or subjects it to a canvass of interests that enables those affected to comment on the standard

Content of Standards. Standards clearly come in a wide variety. Some push parochial interests while others push the state of the art.[**/] They are sometimes lumped together and maligned as reflecting a base, lowest common denominator that are inadequate in their recognition of hazards, or establishment of

---

[*/] See ACUS Recommendation 78-4, Federal Agency Interaction with Private Standard Setting Organizations in Health and Safety Regulation; 1 C.F.R. § 305.78-4 and Section 7(b), OMB Circular A-119, revised October 27, 1982.

[**/] By its very nature, however, a voluntary standard will rarely attempt to push the state of the art much beyond what is technologically feasible at the time of its development.

acceptable levels of risk.[*] Some, on the other hand, who admit to being highly skeptical of the process, have found that consensus standards give vent to the country's experts on a given subject matter and largely reach reasonable results without regard to economic interests.[**] Some agencies are reluctant to rely on them to address a perceived hazard in lieu of a mandatory regulation for fear that not all members of an industry will comply.[***] Similarly, industry members may be reluctant to follow them for fear that not all members of the industry will and that the noncomplying product will be cheaper and hence gain market share (which says, of course, that either the affected characteristic is not appreciated by the purchaser or that purchasers do not want to buy that particular quality). Some standards are clearly far ahead of regulatory agencies in providing protection.[****]

---

[*] See, e.g., Final Report of the National Commission of Product Safety (1970) at 48.

[**] Hamilton.

[***] The degree of compliance with a voluntary standard is often discussed. What is often overlooked, however, is the degree of compliance with a regulation; it is surely inaccurate to think that once a regulation is in place all those who are subject to it meet its requirements.

[****] See MacAvoy. Moreover, the standards address hazards for which agencies have not issued any regulations or in which agencies have not updated the existing requirements. For example, many standards address exposure to chemicals and toxic agents for which OSHA

Footnote continued on next page.

As a result, generalizations about the effect of voluntary standards on technologies to control occupational safety and health are difficult. But, they clearly are an important force. They are important in their own right by codifying the views of those who participated in their development as to what technologies ought to be adopted as a minimum. Moreover, they are influenced by and in turn influence the other forces concerning occupational safety and health technologies.

Incentives to Adopt Standards. While on first blush one might believe that companies and their trade associations have little incentive to develop reasonable standards concerning occupational safety and health technologies, in fact there are a number of reasons to do so. Probably the most important is that the respective officials are also responsible professionals and follow their professional inclinations as to what should be done

---

Footnote continued from previous page.

has no requirement or the standards propose a requirement far below levels that are permissible under existing OSHA requirements. Further documentation can be obtained simply by comparing the list of requirements imposed by virtually any agency with the category of applicable standards.

To be sure, regulations often are promulgated because existing standards are inadequate or afford insufficient health and safety protection. Thus, while a particular interest may quarrel with the balance struck in a standard, it is important to note that at least the standard exists and is providing some protection even while the agency may be working on a mandatory regulation. For an assessment of this relationship see Public Citizen Health Research Group v. Auchter (D.C. Cir. #83-1071, March 15, 1983).

in a particular situation. For example, an industrial hygienist employed by a company is likely to be in that business because he believes industrial health is important. Standardization activities are a method of accumulating that expertise and experience. The standardization process is an outlet for these individuals to do what they believe is called for under the circumstances. Moreover, a standard can enhance their position in a firm, since it may be difficult to persuade management to adopt some technology simply because the employee says it is advisable; a standard shows that many people believe it is appropriate and there is also a reasonable likelihood that other companies will also adopt the technology.

The company may also adopt a standard in the belief it will ward off more stringent -- in its view, unreasonable -- regulation. The suppliers of a product used in the workplace may desire a standard regulating use of the product because it will reduce product liability claims from the employees of its customers because whether a product is "unreasonably dangerous" depends on the way in which the product is used and a standard can influence that. The company may think the standard will reduce its exposure to workers' compensation claims by increasing the level of safety and health of its employees. A company may be interested in standards to offset consumer fears over dangers posed by the product or to enhance consumer acceptance of the product.

It may also be profitable to do so: A standard may increase production or lower costs.*/ In fact, the full range of incentives that cause companies to adopt safety and health technologies also induce them to adopt standards or work on their development. In addition, standardization may be an efficient way of gathering the requisite data and spreading the expense of the resolution of that data into a reasonable requirement. A standard may also arise for competitive reasons: Companies may honestly believe the goal of the standard should be followed, but that no company would adopt it without others following suit and, as described below, voluntary standards are "enforced" in a variety of ways. And, of course, companies may attempt to use standards in an anticompetitive manner to gain market share.

Thus, while we lack any systematic review of either why standards relevant to workplace technologies are developed or what their overall "quality"**/ is, standards as a category cannot be dismissed out of hand, as do some,[*/] and probably play a greater role in occupational technologies than do government regulations.[**/]

---

*/ Some standards that limit the amount of a chemical in the ambient air may be adopted because the escape of the chemical reflects a loss of productive capacities. The standard may lead to standardized production processes that reduce the unit manufacturing costs.

**/ Quality here, like many other places, is largely in the eye of the beholder and depends on their particular values. In this case, it means the perception of risk, the data developed concerning that risk and technologies reasonably available to mitigate risk, and the resolution of the multitude of relevant factors into a standard.

Trade Associations. As a brief review of the NBS Directory makes clear, trade associations are a major source of standards pertaining to their respective industries.[***/] Trade associations also engage in a wide range of activities directly related to occupational safety and health issues.[****/] For example, the

---

[*/] Philo, for example, says flatly, "[Safety standards] represent much less than due care." He may be right as to some, especially older standards, but he is equally flatly wrong as to others since the world is far more complicated than he envisions.

[**/] This is likely true because standards address far more hazards than government programs would ever be able to encompass. Moreover, firms follow voluntary standards because they have an incentive to do so. The precise reasons firms participate in the development of standards and follow their prescripts once developed is an empirical task of major importance. We lack an extensive, systematic analysis of this subject, particularly for non-consumer products and processes.

[***/] Some trade association standards may reflect a consensus beyond that of the association and may also have been adopted as ANSI standards.

[****/] Some of these standardization activities are limited to trade association members, whereas others are developed through a consensus process, usually under ANSI's auspices. As such, they are likely to not reflect the breadth of perspective that a standard developed through a balanced committee would. That is not to say, however, they are not "good" standards; such a value judgment would have to be based on relatively comprehensive research across a variety of standards and situations.

It is important to point out that by their very nature, various groups will believe the standard does not fully reflect their interests. Rather, the standard reflects a compromise of competing interests and must be measured against its original scope and purpose.

Compressed Gas Association compiles a handbook describing "in detail the safest recognized methods, many developed by CGA, for handling and storing gases."*/ The Chemical Manufacturers Association prepares labels for chemicals on their proper handling and warning of their adverse properties. The Health Industry Manufacturers Association published a series of papers for its members on ethylene oxide. It also issued a policy statement that OSHA's standard governing exposure to EtO was inadequate at 50 ppm for an 8-hour time-weighted average. While HIMA did not recommend any specific standard for its members, it did point out that some members were using a 10 ppm standard. Indeed, HIMA determined 68% of its members were using that standard or lower.**/

EtO is a good illustration of the difficulties of trying to rely either on mandatory regulation or on voluntary standards to achieve occupational safety and health. Many industries reduced the exposure to a level far lower than the current OSHA standard that did not address its carcenogenic risk. As the numbers above indicate, the majority of the health care industry similarly adhered to a lower standard, but a substantial portion did not meet the 10 ppm voluntary standard.***/ Thus, even if one would argue that the 10 ppm standard is not sufficient and that a more stringent standard should be followed, OSHA has not done so. In the interim, it is the voluntary standard that is below OSHA's mandatory level that affords protection.[*] This is also the case for the enormous number of hazards -- from chemicals and otherwise -- that are not the subject of a current regulation.

---

*/ NBS Directory at 66.

**/ Comments of HIMA in OSHA Dkt. No. H-200, Advance Notice of Proposed Rulemaking Pertaining to Ethylene Oxide.

***/ It may be inaccurate to describe the 10 ppm as a "voluntary standard" since it appears there is no one standard but rather a variety of individual, narrowly based standards, many developed in house by individual companies.

Trade associations also regularly provide guidance on how to comply with standards, be they voluntary or those issued by a government agency. For example, the American Society of Safety Engineers has said that trade associations regularly marshal their expertise and provide seminars for their members on safety issues.[**] They point out, however, that the seminars cannot continue for long unless they become self-sustaining because of the drain on resources. These standards and advice provide guidance to the association members, large and small alike.

Antitrust Aspects of Standards. Anytime companies get together and agree on something or their trade association recommends a pattern of conduct, antitrust questions are raised immediately. They are unquestionably raised in the area of standardization. Interestingly, given its potential for anti-competitive conduct, the law of the antitrust aspects of health and safety standardization is remarkably sparse. The Supreme Court has said it is permissible for companies to exchange safety-related data and to set standards that protect the public's health and safety or to protect themselves from product liability actions. The Court has also cautioned, however, that standards must not be used as a guide for excluding competitors or facilitating price fixing.

---

[*] See Public Citizen Health Research Group v. Auchter (D.C. Cir. No. 83-1071, March 15, 1983) in which the court reversed a lower court order directing OSHA to issue a temporary emergency standard for EtO but ordered OSHA to expedite its rulemaking proceeding.

[**] *Professional Safety*, June, 1982, at 33.

The Federal Trade Commission has advised that compliance with a standard must remain voluntary. Some cases have held, however, that a trade association can develop rules governing the behavior of its members and can sanction those who do not obey them. The cases so holding are generally those in which the association is established to provide the legitimacy of something -- such as a breed of cattle -- or to establish a network -- such as flowers by telephone -- in which the rules are fundamental to the functioning of the organization. If, however, a standard is not designed to implement the central purpose of the association and, even though voluntary, would result in anticompetitive behavior, it may run afoul of the antitrust laws. While that may be less the case with respect to health and safety provisions, the traditional doctrine serves as a check on association activities.

While it probably did no more than restate what has been the law for a decade, standards writers received a significant jolt in the summer of 1982 when the Supreme Court decided the case of American Society of Mechanical Engineers v. Hydrolevel Corp.*/ The Court held ASME responsible for the anti-competitive conduct of several individuals who occupied dual capacities, one as officials of a company and the other as officials of an ASME committee. They issued an advisory opinion in their ASME capacity that a competitor's product did not meet the requirements of the Boiler and Pressure Vessel Code. The influence of the Code is so strong that the competitor could not market its product unless it complied and, as a result of the negative advisory opinion, it faced bankruptcy. The facts of the case are therefore ugly indeed. If limited to its facts, the case would be of little significance since most standards organizations can and have implemented procedures to prevent the problems from recurring. The longer term effect is likely to be that standards affecting health and safety questions, which by their nature adversely affect some products, must be based on objective information and adequately documented; to an extent, the standards-writing process will be made to more closely resemble the rulemaking procedures of Federal agencies, although they will probably remain more informal and will continue to be built on a consensus. A potential effect, however, could be to make standards-writers skitterish in resolving close questions in favor of stringency.

---

*/ 72 L. Ed. Ed. 330 (1982).

The Federal Trade Commission has also been considering a trade regulation rule that would govern the standardization process. The staff recently (April 6, 1983) issued a report calling for standards-writing organizations to respond in writing to complaints over a standard and cautioned that it will be reviewing on a case-by-case basis whether standards result in an unfair method of competition. The Commission itself has not indicated whether it will ultimately pursue a rule, however.

Because of the potential antitrust exposure, it is not likely that many industry-based trade associations would try to enforce a health or safety standard by excluding a miscreant from its membership, organizing a boycott, or taking some other punitive action. It may, however, attempt to persuade its members to comply. The association may issue a "seal of approval" for complying products on the assumption that the market will then provide a stimulus for compliance. The Federal Trade Commission cautioned recently that seals of approval must be "based on tests or some other objective quality and performance criteria."*/ The Commission entered into a proposed consent order with the National Association of Diving Schools**/ under which the association would not issue its "seal of excellence" unless the product to which it was attached "has been competently, adequately and thoroughly tested in such a manner as reasonable to substantiate wi competent and reliable evidence any such assurance ...." Moreover, the Commission required that an independent testing laboratory conduct the tests or that the public be told that the manufacturer itself performed them. Thus, a seal of approval that is not backed up by adequate evidence may run afoul of the Federal Trade Commission.*/

---

*/ FTC Press Release announcing consent order of National Association of Scuba Diving Schools (May 18, 1982).

**/ 47 Fed. Reg. 31,272 (5/18/82); the proposed order was published for comment and has not yet been made final by the Commission.

Standards in Product Liability Actions. Although the trade association or other standards writer may not be able to enforce**/ the standard directly, significant pressure to follow it, or meet its level of protection in some way, may come from the threat of product liability litigation. For example, the court in Borel noted that as early as 1947 "the American Conference of Governmental Industrial Hygienists, a quasi-official body responsible for making recommendations concerning industrial hygiene, issued guidelines suggesting threshold limits for exposure to asbestos dust."***/

---

*/ A member of the Consumer Product Safety Commission asserted that 11 of 12 models of Christmas tree lights that were surveyed did not meet the standards of the National Ornamental Electric Light Association even though they carried the NOEL seal. Product Safety Letter, September 14, 1981. Although this is clearly outrageous, no enforcement action by a government agency has been reported.

**/ Some standards, while not technically mandatory, are in fact because the market will demand it. For example, Hydrolevel went bankrupt because people thought its product did not conform to an applicable standard; someone would likely have difficulty selling some products not conforming to applicable Underwriters' Laboratories Standards.

***/ 493 F.2d 1076, 1084.

In finding the companies liable, the court thought their failure to warn users of ACGIH's recommended threshold limits was relevant. The standard was, therefore, used in part in determining the companies' duty towards users.

Courts were until recently ambivalent towards allowing the introduction into evidence of standards. Some would not consider them because they are technically hearsay and thus excluded by traditional rules of evidence. The current trend, however, is clearly towards permitting their consideration. Indeed, given the few cases that even mention the issue, they must be used relatively routinely.

Standards are relevant in a products liability action in a number of ways.*/ They are frequently used to show the custom in the industry -- i.e. that the standard is commonly followed. Plaintiffs use the standards to show the defendant did not meet the requisite level of care and hence either that its product is defective or that the defendant had been negligent because it did not meet the standard. They can also be used to show feasibility of an alternative design or the state of the art. Defendants, on the other hand, use them to show that they took reasonable precautions, and in particular that the product is not defective because it meets the custom of the industry. Standards can also be used to bolster the testimony of an expert. They generally may not be used to measure a product that was designed before the standard was developed, however.

---

*/ See Hoffman and Hoffman; Digest.

The extent to which a voluntary standard becomes the standard of conduct in a product liability case appears to be directly proportional to the extent to which it is adopted in the industry and its "quality". In the latter regard, when it is the defendant arguing that it discharged its duty, courts view it as significant when a standard is developed by a professional organization or by a broad consensus instead of the industry itself. Thus, some commentators have argued that if standards are to be used defensively, the quality of the standard itself is in issue, and that it should be relevant whether it is a consensus standard based on objective evidence. Some standards organizations, on the other hand, oppose litigating the validity of their standards in a product liability action. As to the first point, if a standard is widely adopted in an industry and a company does not meet it, it can place a relatively high burden on the defendant to show that its product or process was not defective or unsafe. The persuasiveness of a standard that has not been followed widely would be much less. Trade association standards are used to show what industry experts recommend. Thus, for example, a contractor was held liable for failing to follow recommendations in a manual published by an association of which he was a member.

The Department of Commerce's Model Uniform Product Liability Act[*] provided that the trier of fact should consider custom in the industry and "the product seller's compliance or non-compliance with a non-governmental safety or performance standard, existing at the time of manufacture, ... in determining whether a product is defective." The commentary to the Model Act pointed out that manufacturers argued vigorously that it is unfair to find a product defective when it complies with industry custom and that the custom is likely to incorporate all cost-justified safety features; the analysis also notes there is respectable academic support for the latter assertion,[**] at least when the purchaser is also the user. They also noted that insurers said such a provision would be important in determining the cost and availability of liability insurance. The Model Act did not make conformance with a standard conclusory because of the variety of standards and the problem of whether the standard has been kept current. Moreover, it could be that an entire industry was derelict. This provision[***] was deleted by the time the Model Act became a bill introduced in the Senate.

---

[*] 44 Fed. Reg. 62,714 (1979).

[**] The brunt of this observation is that the cost will reflect that technology which reduces the cost of injuries more than the cost of the technology itself.

[***] Section 107 of the Model Act provides: "Evidence of custom in the product seller's industry or business or the product seller's compliance or non-compliance with a non-governmental safety or performance standard, existing at the time of manufacture, may be considered by the trier of fact in determining whether a product was defective in design ... or whether there was a failure to warn or instruct ... or to transmit warnings or instructions...."

In sum, a standard may be used in determining a company's liability in a product liability action. If the company did not meet a generally adopted standard, a jury may find it persuasive that the product was defective unless the defendant can show it discharged its duty in some other way, such as by a wholly different approach or that the hazard addressed by the standard was not posed by its product. This in turn could lead to significant pressure for members of an industry to adopt relevant standards.*/ On the other hand, a court may look behind a standard and find that it does not provide an adequate level of protection, so that even if a standard is met it will not offer solace. This offers some protection against the feared lowest common denominator or conspiracy of silence, but should not be used to undermine a true consensus standard developed with widespread participation and reasonably updated.**/

---

*/ Informal conversations with a variety of corporate officials indicate they do in fact feel such pressure to conform to standards. The full extent to which standards determine the level of conduct in litigation and the compliance by companies with standards because of their use in litigation would require extensive empirical analysis.

**/ It would seem inappropriate for a court to second-guess the validity of a standard which reflects a consensus among diverse interests, because any such standard reflects a compromise among a variety of competing values and it would not be appropriate to elevate one of them to the exclusion of others. Rather, the standard would reflect a reasonable resolution of the issues. Thus, the review should be more procedural than substantive. For an elaboration on this problem, see Harter [3].

Benefits of Standards. Using voluntary standards, especially those developed by a broad consensus among affected interests, to set the minimum levels of occupational safety and health related technology has many potential advantages over reliance on governmentally issued regulations. First, they can respond to a need relatively quickly and can be tailored to particular hazards more easily than can a regulation which is time consuming and expensive to develop and must necessarily lump many workplaces and practices together in reaching a requirement. Second, they can better tap the practical expertise of those who are directly concerned with the problem from a variety of perspectives; thus they can bring to bear more resources than any regulatory agency can muster.*/ Third, the way a consensus standard is developed can provide a ready means by which the various parties in interest reach a reasonable accommodation of the respective factors involved that is highly akin to the way occupational safety and health standards are set in European countries. Fourth, the way they are enforced means that the standard sets the general duty but an individual company that chooses not to comply retains the ability to prove, at least theoretically, that either the hazard is not raised in its workplace or by its product or that it has provided an equivalent level of protection. Fifth, for better or worse, and deciding which is accurate would require major empirical work, the company can choose to incur liability as opposed to following the requirement.[*] Sixth, standards can -- and are -- written and kept current for far more occupational hazards than OSHA could ever hope to address.

---

*/ See Harter [2] at 19-22.

Conclusion. Standards also have problems of their own. There is always the fear that they will be inadequate and not provide a sufficient level of protection. People who are interested in the outcome may, for one reason or another, not participate in their development and hence be distrustful of them. There is also the ever present danger that firms will not in fact follow the standards and yet incur no liability as a result,[**] and imposing liability through the tort law may entail unacceptably large transaction costs.

---

[*] This could be viewed as good if the liability relatively accurately reflected the costs of accidents, so that the company would be minimizing the aggregate of avoidance costs and the costs of non-avoidance; it is bad if the liability imposed does not reflect those costs, so that less safety is developed than should be.

[**] The fear of non-compliance with voluntary standards must also be tempered against the relative observation that many regulations are not followed either. Thus, before one concludes that a mandatory regulation is needed because a voluntary standard is not followed one must also make the judgment to the extent to which the mandatory regulation would be met.

The extent to which these concerns are real needs to be tested. Some standards are clearly very good and push the state of the art. Sometimes the liability imposed is potentially enormous, and the standards are written against that fear. Sometimes the threat of government action is very real, and private action is stimulated to ward it off. Sometimes all parties significantly affected do sit down together to work out a reasonable approach. Standards therefore provide an important incentive for adopting occupational safety and health technologies. Indeed, when coupled with the various ways they are "enforced", they probably play a far larger role than does Federal regulation.

But, of course, sometimes they are weak and attempt to coopt the field. The full extent of the "quality" and "efficiency" of this approach remains to be determined. Before it will work well the various parties -- companies, beneficiaries, professionals, academics, and government officials -- need appropriate incentives to participate in the development of responsible standards. Some of those incentives have been touched on here, but focusing on that question is a critically important task in achieving the goals of many current regulatory programs.

One important incentive is a creative tension between regulation and standards: standards can address a far wider range of hazards than can regulation, but they may not be as stringent as a regulation that an agency would issue. The threat of issuing a regulation, on the other hand, is also a spur to develop a standard that reasonably addresses a hazard. Since regulations can only address a limited number of hazards they need to be reserved for the truly important areas, with the agency otherwise working to stimulate responsible standards. In that way the agency can husband its resources and achieve the greatest return for its activities. Precisely how to do that, like many other questions in regulation, requires major work and is only now beginning to be developed.

V

NON-STANDARD SETTING ACTIVITIES OF OSHA

OSHA itself can provide significant incentives to adopt control technologies even apart from its promulgating obligatory standards. Most abstractly, its very existence raises the safety and health consciousness of companies, labor, standards-writers, academics, and courts. Its creation by Congress reflects a broad concern with the issue and places it on the national agenda. While its rocky beginning[*/] undoubtedly hurt drastically by diminishing

---

[*/] During the Congressional consideration of the bills leading up to the establishment of OSHA, industry representatives lobbied hard for a requirement that the initial regulations should be built on the voluntary standards developed over the years. While they feared excessive, unreasonable regulation, the result could hardly have been worse than what did occur when Congress acceded to business' wish. Notwithstanding substantial doubt about those standards, Congress obligated OSHA to adopt "as soon as pacticable ... as an occupational safety or health standard any national consensus standard, and any established Federal standard, unless [it] determines that the promulgation of such a standard would not result in improved safety or health ...." § 6(a). Thus, OSHA was ordered to adopt all standards that were relevant to occupational safety or health issues; it was not permitted to edit them, nor was it to follow the normal rulemaking processes of the Administrative Procedure Act. The standards were a motley mess: some were ancient; some would be satisfactory if limited to their original purpose and scope, but they were not; some were exhortatory and were never intended to be mandatory; some were manufacturing specifications; some were simply poorly drafted. They infuriated business, even though implemented at its urging, and they established no foundation on which OSHA could build. The "OSHA jokes", in which standards were enforced in absurd situations, resulted and ridiculed the agency for what was substantially the fault of Congress. Revision of those standards has been an OSHA priority since its creation and work on it continues; while OSHA's widely publicized "End of Nitpicking" campaign ridded the Code of Federal Regulations of most of

Footnote continued on next page

respect for the agency and hence its goal, companies are still likely to take the issue more seriously because of OSHA's existence. It would seem that the requirement to comply with OSHA standards would mean that companies are more likely to employ health and safety professionals and to be more prone to follow their advice. OSHA's consultation programs can also provide direct advice on health and safety related technologies. Finally, OSHA can under some circumstances enforce voluntary standards. Whereas product liability litigation may induce companies subject to such suits -- which includes suppliers of products used in the workplace, but generally not those in an employer/employee relationship -- OSHA's enforcement of these standards is directly applicable to the workplace environment.

General Duty Clause. Section 5(a)(1) of the Occupational Safety and Health Act, generally referred to as the "general duty clause", provides:

Footnote continued from previous page

the original absurdities, problems remain. For example, the primary standard governing machine guarding still offers only examples and ends with the unhelpful "etc." 29 C.F.R. §1910.212(a). The machine guarding standards cover a small fraction of machines and are hopelessly out of date. OSHA began revising Subpart L -- Walking, Working Surfaces -- in 1973 and, at least last fall, is about where it was then in accomplishing the task. For a discussion of the initial standards and their problems, see Harter [1]; MacAvoy; and Harter [4].

> Each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.

The legislative history of the provision is brief, but what there is indicates it was intended to be of scant importance.[*] Rep. Steiger, who was a sponsor of the Act and played a major role in securing its passage, explained the conference report to his colleagues by saying that "recognized hazards" are "the type that can be detected on the basis of human senses. Hazards which require technical or testing devices to detect them are not intended to be within the scope of the general duty requirement."[**] On the other hand, the term "recognized hazards" arose from an amendment offered by Representative Daniels. He felt the term "readily apparent" that was in the bill sponsored by Steiger was too narrow. Thus, the floor manager explained the broadened perspective in terms of his original, narrow definition. At any rate a contemporaneous article in the Harvard Law Review said,

> "Steiger further suggested specific standards alone were the appropriate way to regulate hazards not detectable by the senses. Steiger's limitation of recognized hazards is neither confirmed nor contradicted elsewhere in the

---

[*] Representative Daniels offered an amendment to broaden the application of the general duty clause to that proposed in the bill being considered on the floor and as to his broader standard he explained, "Most safety situations will be covered by standards, but some provisions must be made for the occasional unique situation that does not fall within a standard."

[**] 116 Cong. Rec. 11,899 (Daily Ed. of 12/17/70).

legislative history."*/

Whatever the legislative history, OSHA early on took an expansive view and the courts agreed. Its compliance manual said,

> A hazard is "recognized" if it is a condition that is (a) of common knowledge or general recognition in the particular industry in which it occurs, and (b) detectable (1) by means of the senses ... or (2) is of such wide, general recognition as a hazard in the industry that even if it is not detectable by means of the senses, there are generally known and accepted tests for its existence which should make its presence known to the employer.

A court quickly sustained that view by upholding a citation for the excessive concentration of airborne lead. The court rejected the argument that the hazard had to be detectable by the senses. It found the general duty clause was applicable, even though OSHA had issued a standard applying to lead concentrations that was not yet effective, because there had been a national standard for airborne lead that had been widely recognized in the industry for many years; it is therefore reasonable, the court reasoned, to require the company to supply the level of safety provided by the standard, even though monitoring equipment was required to determine the hazard that was recognized.**/ The defendant attempted to show that it had put in place an alternative way of preventing the hazard of lead poisoning by monitoring the level of lead in its employees' blood. The company presented experts who testified that that was a suitable method, but the court found it would be better to comply with the voluntary standard limiting airborne concentrations of lead. Thus, the court adopted the Daniels' explanation of the general duty clause and it required the company to comply with a recognized standard by finding the alternative followed by the company was not sufficient to abate the hazard.

---

*/ Morey.

**/ American Smelting and R. Co. v. Occupational Safety and Health Rev. Com., 501 F.2d 504 (8th Cir. 1974).

Criteria of §5(a). Subsequent cases have made clear that if a company recognizes a hazard and takes action to combat it, to sustain a violation of the general duty clause, OSHA must show the precuations taken would be unacceptable to reasonably conscientious safety experts familiar with the pertinent industry. Further, if a company recognizes the hazard, it need not be generally recognized in the industry as a whole.

The hazard need not be known to each and every member of the relevant industry for it to be "generally recognized." But it must be widely known in the industry in question. Thus, for example, if a hazard is recognized in one industry but not another, the general duty clause cannot be enforced against members of the latter industry.[*/] An example of that arose when a citation was issued against oil riggers for allowing employees to ride the derrick hook up the drilling platform; while "riding hook" is a known hazard in the construction industry it was not proscribed in the drilling business.

Voluntary standards are frequently used to show that a particular hazard is generally recognized in the industry. For this purpose, however, they are relevant only if they are widely followed in the industry in question -- or were prepared by the industry itself -- both of which demonstrate that the industry generally recognized the hazard. Thus, a company that did not follow the recommendations of the relevant trade association was cited. On the other hand, if the standard is not widely adopted in a particular situation, it does not bear on the issue. For example, OHSA cited a grain elevator for failing to follow an ANSI standard, but the company escaped liability by showing the cited provision was not part of a standard designed to be followed but rather was provided only for informational purposes. Nor do union work rules that are not broadly followed in the industry serve to demonstrate "recognition" of a hazard.

[*/] It may be, of course, that the hazard addressed by the standard is so obvious as to be evident to anyone, in which case the fact that one industry has a standard addressing the hazard but another does not does not serve to protect a member of the latter industry from being charged that the hazard is "recognized in its industry." For example, it seems readily apparent that flinging bricks out a window is dangerous to men working below and the fact that one industry had a standard admonishing employees not to do that would not protect a company in an industry that had no such standard. Usery v. Marquette Cement Manufacturing Co., 568 F.2d 902 (2d Cir. 1977).

Sometimes companies are able to show the hazard alleged by OSHA is not "generally recognized" because it is not the subject of a standard covering the industry or related problems. The theory is that if there were a widely perceived hazard there would be a correlative standard.

Simply because the company complies with a standard universally recognized in the industry does not necessarily protect it from a § 5(a)(1) violation, however. For example, tradition and applicable standards required only a "blue flag" to caution against moving trains on sidings where they were being unloaded or maintained. A company that followed the rule was nonetheless cited for failing to provide derailers since they were technologically feasible and the blue flag did not offer sufficient protection.

A hazard may also be "generally recognized" because it has been brought to the industry's attention. Thus, for example, a company was cited for transporting migrant workers while standing in the back of a truck. The hazard was recognized since an OSHA representative had twice addressed large audiences of growers concerning the danger and the relevant trade association had met to discuss the problem.

A voluntary standard can also be used by OSHA to demonstrate that a feasible way of protecting against the hazard exists. But, OSHA is not enforcing the voluntary standard itself under the general duty clause. Thus, it is not a violation of § 5(a)(1) solely because the provisions of the standard were not met. Rather, a standard that is widely adopted in the industry, or which was developed under industry auspices, is evidence that the hazard is "generally recognized" and that a feasible technology exists to address the hazard. Even then, the company need not follow the standard's prescriptions so long as it has adopted some action to combat the hazard that would be acceptable to reasonably conscientious safety experts familiar with the industry.

As OSHA recently pointed out, there are other ways of demonstrating recognition of a hazard: statements of industry experts; implementation of abatement programs by other industry members; manufacturer's warnings on products used in the workplace; studies conducted by the industry, its employees, the government, or insurance companies.[*/]

Use of Standards. As a result of the general duty clause, OSHA can take action to make sure that some companies -- the "Bad

---

[*/] OSHA Instruction for General Duty Clause Enforcement, CPL 2.50 (3/17/82). OSHA notes in the document that the use of the general duty clause has grown to approximately 3,200 citations in FY 1980 and that this has sparked criticism. Given the relatively limited number of specific OSHA standards and the enormous variety of workplaces and related voluntary standards, that does not seem like an excessive number, especially when compared to the number of citations against some of the general OSHA standards.

Footnote continued on next page

Apples" -- do not ignore hazards that others in the industry recognize and undertake to abate. This should help alleviate to some extent a company's reluctance to follow a standard for fear that others in the industry will gain a competitive edge by ignoring it.

Under this approach, OSHA can use a voluntary standard that addresses a particular hazard and that has been accepted by the industry as the basis for finding a company in violation of the general duty clause. It is important to note that the general duty clause is thus used only against deviants. It is not imposed as a way of enforcing a standard that is not widely accepted, unless there is clear independent evidence to suggest the industry generally recognizes a substantial hazard. If OSHA were to attempt to enforce a standard that has not been followed generally, it could serve as a powerful disincentive against developing new voluntary standards since they could effectively become mandatory when issued. Rather, the general duty clause is used to bring companies up to the level of care of the industry except in those instances when the industry as a whole does not take action in the face of a perceived hazard.[*/] As the migrant worker case shows, OSHA can take

---

Footnote continued from previous page

The general duty clause may not be cited when there is an OSHA standard addressing the standard. Thus, for example, OSHA may not cite against the general duty clause for failure to restrict employee to x ppm of a particular chemical even if it is generally recognized in the industry that sound practice requires it while the OSHA standard would require only 10x ppm.

*/ The "blue flag" rule described above is an example in which the industry recognized a hazard but took insufficient action to abate it. Thus, the standard and work practices were used as recognition of a hazard but it seemed clear that the prescribed remedy was not sufficient.

action through publicity, meetings, and professional activities to raise an industry's recognition of a hazard. It could, in that way, seek to implement a standard through the general duty clause. Usually, however rulemaking is the proper course for raising the overall level of performance of an industry.

OSHA uses voluntary standards in other ways, too. OSHA recognized that it was unable to revise its standards every three years to keep pace with the National Electric Code, and difficult inconsistencies could result with its continued reliance on an out of date NEC. It therefore worked with the National Fire Protection Association in developing a consensus standard to address electrical hazards in the workplace. NFPA empanelled a new committee to develop such a standard and OSHA used the result as a notice of proposed rulemaking.[*/] It also included appendices listing voluntary standards that could be used as guidelines for complying with obligatory regulations.

OSHA's standard for fire protection also lists guidelines for complying with the specified duties. Moreover, it includes an appendix of relevant voluntary standards that OSHA regards as acceptable ways of complying with the mandatory regulations. Under this approach, a company following the guideline will be

---

[*/] 44 Fed. Reg. 55274 (9/25/79).

regarded as complying with OSHA's mandatory standard. But the firm need not comply with the standards listed in the appendix and can discharge its duties by other methods.[*/]

Thus, OSHA can and does use efforts developed in the private sector in its quest "to assure so far as possible every working man and woman in the Nation safe and healthful working conditions."[**/] It does so by using them as advisory guidelines on how to comply with mandatory requirements and as regulatory guides which are acceptable but not necessary ways of complying. It uses them in enforcing the general duty clause as a way of bringing companies that are lagging behind the industry as a whole or when an entire industry is ignoring a clearly perceived hazard.

Standards Writing. OSHA staff meets periodically with standards writing organizations to exchange information as to OSHA's needs and the standards writers agree to provide technical support and information as to standards under development in the private sector.[***/] OSHA personnel also serve on various standards writing committees

---

[*/] 45 Fed. Reg. 60656 (9/12/80); see MacAvoy for a general explanation of this approach.

[**/] Sec. 2, Occupational Safety and Health Act of 1970.

[***/] See Memorandum of Understanding between the Occupational Safety and Health Administration and American National Standards Institute, November 22, 1976, as reprinted in Standardization News, (May, 1977).

and hence are able to influence the outcome of those deliberations. On the other hand, many individuals have indicated they thought OSHA could do far more in using these resources. Several within standards organizations have said far more could be done to leverage OSHA's resources by influencing voluntary standards towards obtaining a broad array of high quality standards applicable to occupational safety and health.*/

OSHA probably could also do more in developing information and advice and addressing specific hazards that could then be used in § 5(a) and product liability actions. OSHA's strategy would have to be carefully orchestrated, however, if it were to be effective and not a waste of resources. If it simply were to make pronouncements without underlying support or recognition of problems, it would probably be a waste of time. On the other hand, if the information were credible it could provide a highly worthwhile purpose, even if not obtaining levels that might ultimately be reflected in OSHA regulations. The information could be used by employees making their own choices, by unions in bargaining for occupational safety and health protection and wage premiums, in product laibility actions, and in § 5(a) actions. The level of protection achieved would likely be more modest than would be achieved in an OSHA regulation, but that would have to be balanced against other limitations of relying on regulations.

---

*/ See Harter [4], Part III.

VI

INSURANCE

Effect of Insurance. Insurance, by its very nature, affects a firm's incentives concerning the adoption of occupational safety and health technologies. On the one hand, it diminishes the incentive to invest in safety and health programs by reducing the firm's exposure from the consequences of accidents and illnesses, be it in the form of product liability or workers' compensation actions. Moreover, to the extent the premium paid for insurance coverage is not reduced by the cost of implementing a program, the return to the firm on its investment is correspondingly reduced and its incentive to invest is thereby dulled.

On the other hand, insurance provides some important incentives. For example, two major safety programs originated by insurers attempting to control their risks. In one, at a time when exploding boilers were a major hazard and immediately following the explosion of a steamship that resulted in a substantial loss of life, a company agreed to insure boilers against explosion, but only on the condition that the company inspected them first to determine that they met the safety standards developed by the company. The resulting program provided strong financial incentives to adhere to the standards and the level of safety was thereby improved. The second example of the establishment of a safety program is the creation of Underwriters' Laboratories to aid insurers in assessing the safety of electrical products, which were at the time an innovation of uncertain risk. UL has clearly had a substantial effect on electrical safety since its founding, and much of its activity results from a belief that products will sell better if they have been tested and listed by UL. In these two instances insurance provided the stimulus to develop control technologies and firms with the financial incentives to adopt those technologies.

Insurance is also a mechanism by which experiences with various technologies can be transferred, by means of rate differentials and by direct consultation between the insurer and the firm. For example, the American Insurance Association and the Alliance of American Insurers conducted a project in Florida in conjunction with the Florida Department of Labor and Workers Compensation program that provided intensive safety and health guidance to small businesses.*/ Finally, insurance can provide a financial incentive to adopt control technologies to the extent the investment is recouped in the form of reduced premiums. For example, Fortune Magazine estimated that DuPont merits a savings of $26 million annually on its workers' compensation expenses over what it would have to pay if its accident rate were merely the industry's average, instead of the industry's best.[*/] Fortune similarly reports that some contractors pay as much as four times more than others for workers' compensation coverage because of their differing experience and that that can result in as much as $3.2 million savings on a $100 million job -- a rather hefty incentive.

---

*/ Professional Safety, June, 1982 at 33. The symposia included presentations on "containing operating and workers' compensation costs"; practical industrial safety programs; controlling common safety and health exposures; inspecting your workplace; effective employee training; accident investigation and analysis; and the role of Florida State Program of Safety and Health. One of the sponsoring organizations said it felt that "These symposiums not only provided a presentation of services and assistance to insured businesses in the state of Florida, but also brought about a communication familiarization for each participant with the services, techniques and expertise that is available in the state." They "provided a meaningful experience for all." Letter from Thomas E. Murray, Manager, Workers' Compensation Division, Engineering and Safety Service, American Insurance Association.

While these may be fairly dramatic examples, on a more routine scale, insurance does provide some incentives for the adoption of safety and health control technologies, but its overall effect remains unclear.

Coverage. The organization and functioning of the commercial insurance market, including coverage for product liability and workers' compensation, is enormously complex. What follows is necessarily a brief overview as it affects the topic at hand. It is based largely on the findings of the Interagency Task Force on Product Liability. Its contractor conducted extensive interviews and analyzed a number of files in compiling its report.

[*/] Fortune, September 6, 1982 at 68.

The report is an excellent introduction to the complicated world of insurance.[*/]

The effect of insurance sometimes comes immediately when a company applies for coverage and the insurer is for some reason reluctant to provide it. Most insurance companies develop guidelines to be considered when deciding whether or not to accept the risk. Sometimes they urge that certain risks be avoided altogether or that some be accepted only after a survey is conducted by a loss control specialist. The insurer may, of course, decline a policy for a company that has had a particularly bad record or is particularly vulnerable to large losses. Carriers are typically cautious in providing product liability coverage for the following products:

- aircraft parts
- pharmaceuticals and drugs
- certain industrial machinery and equipment[**/]

[*/] Interagency Task Force, Insurance Study.

[**/] Some industries, when faced with difficulty in obtaining insurance coverage, have banned together to rectify the situation. For example, producers of industrial grinding wheels found themselves in that situation. The Grinding Wheel Institute sought an insurer and a research organization, and together they developed a two prong program. The first was to reduce the number of accidents through strict loss control standards: the insurer would review the design, testing, fabrication, quality control, and labeling procedures for the production of grinding wheels, and

Footnote continued on next page

- organic chemicals
- medical devices
- explosives and ammunition
- other products, especially those with a long, useful life that are capable of causing major harm either alone or as a component of another product.

Rates. Notwithstanding the general guidelines concerning whether to accept a risk, the decision whether to accept a policy and under what conditions (e.g. large deductible or low limit) is largely one of judgment. Certainly one of the major considerations entering into a company's decision whether to insure is the amount of potential business presented. The Report indicates that large companies -- those with more than $10 million in annual sales --

---

Footnote continued from previous page

would write the coverage only if satisfied that industry standards were met. The second prong was to develop an aggressive defense by training attorneys in the technical aspects of grinding wheel construction and operation. Thus, a single insurer undertook most of the industry's coverage and developed loss control standards that had a significant influence on the industry. Unfortunately, however, claims have risen recently and the resulting premiums jumped more than 50% in the mid 70's. The Interagency Task Force attributes this to the lack of major advancements in control technology; the fact that adherence to the standards is only voluntary (the Report provides no insight into the degree of compliance or whether the insurer either refuses coverage or enforces the standards during coverage); and the decline of traditional defenses in product liability actions.

obtain some sort of coverage, but that some smaller firms have encountered difficulties in securing it for product liability.

The rates companies pay for insurance are developed in several ways. The starting point for each approach is in the determination of a "basic rate". If the products involved have a sufficient history, the rates may be determined actuarially; these are called "manual" rates. By and large, these are low exposure products. For those products and processes where there is insufficient information to develop a reliable prediction of exposure, the rates are based on educated judgment; these are called "(a) rates". The Insurance Services Office collects information on risks and develops guidelines for "(a) rates" that it sends to its member companies for use in developing actual basic rates.

These basic rates are then modified in a number of ways. The first is by the "traditional" method. In this process, the company's own loss experience record is taken into account. The basic rate is further modified by a series of highly subjective credits and debits that reflect on the overall quality of the insured's operations. Another way of modifying the basic rates is to break the premium down into a unit of measure -- such as the number of products manufactured, the number of employees, or the gross sales -- and then applying the premium per unit to the total number of units. In this case, the total premium is not determined until the end of the policy year when the number of units is known. Yet another way of modifying the basic premium is to develop a formula by which the rate will be adjusted according to actual experience during the policy term. Thus, in this case, the premium is calculated retrospectively. This process is used for the "tough" risks because it provides the insured with greater safety incentives.

Overarching all of this is the underwriter's judgment: In setting the final rate, the underwriter will exercise a considerable amount of discretion.

As a result of the way premiums are set, small companies tend to pay a rate based on industry averages because of the lack of a statistically significant experience or other factors on which to base a modifying judgment. But, large companies have at least some incentive to develop safety and health programs for their products and processes since they will save on their insurance premiums. The full effect of the incentive and whether it tends to the optimum level of safety and health would, of course, depend on the relationship of the premium savings and the investment costs. Small business tends to lack that incentive since its premiums tend to be insensitive to favorable experience.

Loss Control Surveys. In deciding whether to underwrite the risk and at what premium, insurers frequently conduct a survey of the firm. Although the trend appears to be growing, that is especially the case if the risks presented are on the insurer's guidelines for caution. A loss control specialist will survey the operations and make recommendations for improvement, oftentimes based on consensus standards or sound industry practices. For example, when making a survey for workers' compensation coverage, the survey would be on the alert for environmental hazards and ways they can be prevented; it would also look to see whether machines are guarded and fire protection provided; and, importantly, they are aware that probably the most important factor is the commitment of management, so they look for a corporate policy concerning worker safety and health. The insurer may conclude from the survey that it does not want to provide coverage or only a limited form of coverage. It may also decide that it will provide coverage only if certain of its loss control recommendations are followed. Or, it may decide to accept coverage but tailor the premium to the degree of compliance. While these recommendations are only voluntary, they frequently carry with them a financial incentive, and the Interagency Report reports that more and more companies are recognizing the importance of complying with the recommendations.

Many of the loss control surveyors are generalists, without specific training in the particular industry. Some companies, however, have developed more extensive expertise in areas where they write substantial insurance. In these cases, the insurer may have testing facilities, quality control engineers, and other technical experts who can both review operations to make specific recommendations and to assist in claims defense.

The loss control activities are both a method of "technology transfer" by which a company -- large or small -- is made aware of available safety and health technologies and the firm is provided with a financial incentive to comply with the recommendations in the form of a reduced insurance premium. One senior insurance company executive indicated in a discussion that his company surveyed the workplace for more than 5,000 chemicals and made recommendations as to their proper handling; as to some, if the recommendations were not followed, the company would either decline coverage or charge a large premium. His company also reviewed what substances had been used in the workplace in the past and how they were handled when setting premiums since that could influence the claims that could be made for diseases that manifested themselves during the policy year. While, of course, a firm cannot do anything about what happened before, this way of calculating a premium would demonstrate to the firm that *if* it does not take preventative action now it will incur increased premiums both currently and prospectively. While information transfer in any event will result from the survey, like before, the extent of the incentive will depend on the relationship of cost to savings.

Incentives for Loss Control. Some people have argued that insurance companies lack the incentive to provide adequate loss control advice since their income is derived by adding a profit margin to the expected loss experience; if the risk is lowered, so they reason, so is the premium and so too is the profit. On the other hand, loss control assessments are a way for insurance companies to predict for their own use the extent of payout, and hence they have their own need to conduct such a review. Moreover, the insurance companies also compete for the patronage of prospective insureds and providing such consultation is one way; price and various aspects of coverage -- such as deductibles and maximum limits -- that are based on the surveys are others. Whatever the theory, companies clearly do provide the loss control surveys and recommendations. The Interagency Task Force indicates the surveys are quite extensive. Several insurance companies have also advertised that they are an important part of their service because they result in lower premiums and fewer losses. On the other hand, several knowledgeable people who were interviewed indicated that they did not make a great deal of difference in corporate performance. What the actual effect is would require additional research.

Another caveat should be borne in mind with respect to the incentives provided by insurance. Because occupational diseases have historically not been fully compensated under worker's compensation or the tort law, it may be that insurance premiums are not very sensitive to actions that influence the incidence of disease. An insurer could well reason that potential liability is doubtful and in any event far into the future so that the present value of any savings in ultimate payout is very small and hence would not discount a premium very much for adopting appropriate control technologies. That in turn would not provide much of a stimulus to the company.

On the other hand, there has been much litigation over the coverage for disease and that is a cost to the insurer the savings of which could be passed on in the form of reduced premiums. Moreover, the asbestos, DES, and Agent Orange litigation stand as dire warnings of disasters that can strike. An insurer may also want to avoid the recurrence of these problems by appropriate surveys of workplaces and charging premiums that take into account the possibility of a long term disaster, in which case the discounts could be substantial. Again, like so many questions in this area, the current practices -- which are undergoing substantial change -- would need to be reviewed to determine their incentive effect on companies.

VII

CONCLUSION: THE NEED TO LOOK TO INCENTIVES

Command and control regulation can, even under the best of circumstances, reach only a small fraction of the significant hazards of the workplace. Their number is necessarily limited and the coercion resulting from direct enforcement is likewise limited. Thus, an effective occupational safety and health policy must look to the various incentives a firm has to adopt appropriate controls. The incentives operate in subtle, complex, and often unforeseen ways; Their interaction is even more difficult to track. But, paying attention to them and how they relate one to another and to regulation is a vitally important aspect of achieving occupational safety and health.

For example, industry may address a hazard long before it is on any agency's agenda. It may do so because it believes it is the correct, responsible thing to do; it may do so to avoid more stringent regulation or to provide the inherent flexibility of the standards approach as opposed to mandatory regulation; it may seek to lower its insurance premiums or avoid litigation either by adopting a standard already in place or by developing a suitable control; it may be responding to pressure from its employees or others in the industry may be compiling and the firm may fear it will be liable under § 5(a) for failing to address a recognized hazard; the company's suppliers may have included safety technologies or warnings in their products to reduce their exposure to product liability actions. The action may come as the result of a voluntary standard which may have been initiated outside the industry, such as by a professional organization, an insurer, a public interest group, or some other interest that is affected by the subject matter, and the industry feels pressure -- which can take many forms -- to comply.

Clearly, however, in some situations companies do not develop adequate standards or do not follow one that is. Sometimes the action companies take "voluntarily" is adequate to address the hazard -- in terms of reducing the aggregate cost of accidents and illnesses. Sometimes, however, it is not and sometimes the action taken is not as stringent as would be a regulation addressing the same hazard. That demonstrates the need for a variety of approaches and understanding of how they relate one to another.

We currently lack that but need to focus more attention on how the various stimuli can be used to accomplish society's goals. Whatever else, companies currently have a variety of incentives -- much more so in safety than in health -- to address hazards. What is needed is to coordinate and reinforce these incentives -- including direct regulation -- to achieve society's goals.

Table 2
Principal Functions Performed by Product Safety Units: All Companies

Function	Percent of product safety units performing indicated function: In nondivisionalized companies (%)	In divisionalized companies: At corporate level (%)	At group level (%)	At major division level (%)	At minor division level (%)
Evaluating the safetyworthiness of new products	87	46	24	55	41
Investigating product safety failures	87	46	65	30	62
Liaison with safety regulatory agencies	80	62	39	20	77
Evaluating and/or preparing product use instructions	76	43	57	26	57
Auditing and testing the safety-worthiness of existing products	70	35	53	25	48
Setting safety performance standards for finished products	70	41	50	25	54
Evaluating patterns and trends of safety failures	67	38	43	22	51
Educating company employees in product safety matters	67	52	49	28	65
Processing product liability claims	65	72	33	19	85
Setting quality control standards for manufactured products	65	23	30	59	48
Setting safety standards for raw materials	63	50	53	25	42
Regulatory record keeping	58	33	40	19	44
Reporting safety defects to regulatory agencies	52	46	25	15	55
Planning safety education programs for products users or other outsiders	50	47	43	22	57
Managing product recall campaigns	4	3	2	1	3

Source: Reproduced from McGuire 1979, p. 53

Note: Based on reported practices of 242 divisionalized and 46 nondivisionalized firms, for both full time and part time product safety units

BIBLIOGRAPHY

Ashford, Crisis in the Workplace, (MIT Press 1976).

Barth, Workers' Compensation and Work Related Illnesses and Diseases, (MIT Press 1980).

Biernbaum and Wreshel, California Supreme Court Adopts a Manufacturer Liability Exception to the Exclusive Remedy Provision of Workers' Compensation, 17 Forum 939.

Calabresi, The Cost of Accidents (Yale University Press 1970).

Chelius

Liability for Industrial Accidents: A Comparison of Negligence and Strict Liability Systems, 2 J. of Legal Stud. 306 (1976).

Workplace Safety and Health, American Enterprise Institute 1977).

Chumas, Ed., Directory of the United States Standardization Activities, (NBS Special Publication 417 1975).

Darling-Hammond and Kniesner, The Law and Economics of Workers' Compensation (Institute for Civil Justice of the Rand Corporation 1980).

Digest, Admissibility into Evidence on Issue of Negligence, of Codes or Standards of Safety, Issued or Sponsored by a Governmental Body of Voluntary Association, 58 ALR 3d 148 (1974).

Eads, Increased Corporate Product Safety Efforts: A Substitute for Regulation? in Bardach and Kagan, Social Regulation: Strategies for Reform (Institute for Contemporary Studies 1982).

Hamilton, *The Role of Non-Governmental Standards in the Development of Mandatory Federal Standards Affecting Safety and Health*, 56 Tex. L. Rev. 1329 (1978).

Harrison, *Managing Safety and Health*, 32 Lab. L. J. 571 (1981).

Harter

In Search of OSHA, Regulation (Sept./Oct. 1977)

Negotiating Regulations: A Cure for Malaise, 71 Geo. L. J. 1 (1982).

The Political Legitimacy and Judicial Review of Consensual Rules, 32 Am. U. L. Rev. ______ 1983 (forthcoming).

Regulatory Use of Standards (U. S. Department of Commerce NBS GCR 79-171 1979).

Hoffman and Hoffman, *Use of Standards in Product Liability Litigation*, 30 Drake L. Rev. 283 (1980).

Interagency Task Force on Product Liability

Volume I, *The Insurance Study* (U. S. Department of Commerce Report No. ITFPL-77/03 1977).

Volume II, *Legal Study* (U. S. Department of Commerce Report No. ITFPL-77/02 1977).

Johnson, *Compensation for Occupational Illness*, Annals of New York Academy of Sciences 205 (1981).

MacAvoy, Ed., *OSHA Safety Regulation* (American Enterprise Institute 1977).

Morey, *The General Duty Clause of the Occupational Safety and Health Act of 1970*, 86 Harv. L. Rev. 988 (1973).

Note, *Tort Actions for Cancer: Deterrents, Compensation, and Environmental Carcinogenesis*, 90 Yale L. J. 840 (1981).

Philo, *Use of Safety Standards, Codes and Practices in Tort Litigation*, 69 Notre Dame L. Rev. 1 (1965).

Posner, *A Theory of Negligence*, 1 J. of Legal Stud. 29 (1972).

Prosser, *The Law of Torts* (West Publishing Company 1955).

Smith

The Occupational Safety and Health Act (American Enterprise Institute 1976).

"Protecting Workers' Health and Safety," in Poole, *Instead of Regulation* (Lexington Books 1982).

Trauberman, *Statutory Reform of "Toxic Torts": Relieving Legal Scientific, and Economic Burdens on the Chemical Victim* (Environmental Law Institute 1983).